Philips LightMaster

KNX Application Guide

PHILIPS

Philips LightMaster Application Guide version 1.0

Specifications subject to change without notice.

Contents

1 About this Guide

1.1 Topics

1.1.1 Introduction

Chapter 2 outlines the advantages of networked lighting control including the possibility for energy saving, flexible functionality and enhanced comfort and describes the features and benefits of the Philips LightMaster product range.

1.1.2 Ways of Control

Chapter 3 contains multiple tutorials covering lighting control topics, such as scheduling, monitoring, occupancy control, light level control, personal control, and building management system integration.

1.1.3 System Overview

Chapter 4 describes the hardware modules available and gives typical example of how each device is connected and used.

1.1.4 Solution Design

Chapter 5 details the process for selection and placement of sensors user interfaces and actuators, application conventions and structure of KNX control networks and DALI lighting networks.

1.1.5 Office Application Example

Chapter 6 provides an example of a typical office layout with equipment, interfaces and functions required.

1.2 References

The Philips LightMaster range of products complies with international standards KNX (ISO/ IEC 14543-3) and EMC standard (electromagnetic compatibility/elektromagnetische Kompatibilität).

For further information about KNX and ETS refer to the KNX Association website

http://knx.org/

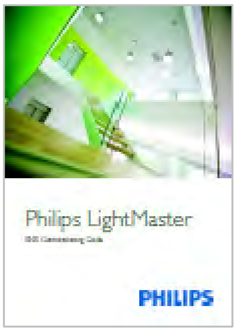
It is assumed that readers have acquired specialist Lighting Control and KNX knowledge before commissioning LightMaster products. In depth technical knowledge is provided in the form of a face-to-face LightMaster training module available internationally from the Philips Controls Training Academy.

1.3 Related Documents

The following PDF documents are available for download via the web at:

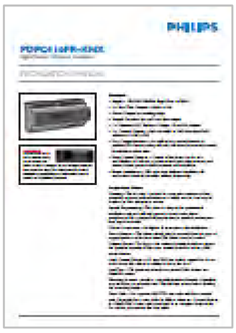
http://www.philips.com/knx

Application Guide



Commissioning Guide

Service Manual



Installation Manuals

Data Sheets

1.4 Technical Support Contacts

Contact Controls, Systems & Services, Philips Lighting call desk for assistance with hardware or software questions:

1.4.1 Phone

Call desk +800 7445 4775 Europe

Call desk +61 2 8338 9899 Australia, New Zealand

1.4.2 Email

knx.info@philips.com

1.4.3 Web

http://www.philips.com/knx

1.5 Conventions

Caution: highlights safety issues or where there is a risk of permanent damage to equipment.

Note: highlights important factors you need to consider.

Tip: highlights shortcuts, accepted conventions and best practice.

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2 Introduction

As an industry-leading innovator for over 25 years; Philips control systems are the solution of choice for a wide range of energy management and architectural lighting control applications. Philips is synonymous with the creation of sophisticated, user friendly and energy-efficient lighting control solutions for a wide range of industry sectors. Philips experience in light sources and controls now adds this recognized lighting know-how to the open world of KNX and DALI, to provide maximum energy savings, comfort & flexibility.

2.1 Welcome to Philips LightMaster

Philips specializes in the provision of end-to-end intelligent lighting control systems, rather than just products. We know that the critical link between light sources and a fully integrated environment is the control capability. The LightMaster control infrastructure supports the fully integrated environment that is encompassed in the KNX and DALI industry standards.

When combined with the broad selection of Philips Lighting's energy efficient luminaires, the LightMaster range of controls will allow users to create not only an energy 'efficient' solution, but also an 'effective' one with the distinctive ability to transform office environments.

At a glance

- Philips Lighting Expertise – We know lighting
- Sense and Simplicity of design that just works
- Hardware is kept to a minimum with smart multifunctional devices
- Reduced installation and wiring costs with sensors and switches on DALI network
- Faster and more reliable installation using structured cabling
- Single device to control the required lighting protocol; DALI, DSI and 1-10v
- No ceiling clutter, given low profile aesthetics of universal sensors
- Fully scalable and suited to both large and small installations

2.2 Why invest in lighting?

For the Office segment in particular, lighting is seen as 'low hanging fruit' for reducing operational costs, saving energy, lowering your carbon footprint and contributes significantly to Green Building Certification. So whether you are a specifier, a builder, a systems integrator, a facility manager or a building tenant or owner you'll find very tangible payback and productivity improvement opportunities through upgrading your existing installation or 'designing in' controls in your next project.

"Lighting controls will improve your bottom line as well as the wellbeing and performance of your organization

- The installation of energy-efficient lighting (such as LED) in new buildings is not enough. New and existing light sources, when combined with improved optics in luminaires, provide far greater 'efficiency'. But the inclusion of controls ensures the 'effectiveness' of the installation.
- 80% of the lighting in buildings is old technology and the addition of controls can give immediate savings and operational efficiencies that will enhance the users experience and provide a better bottom line for the business.
- Only 1% of buildings use lighting controls such as basic presence detection and daylight controls.

2.2.1 Office Energy Consumption

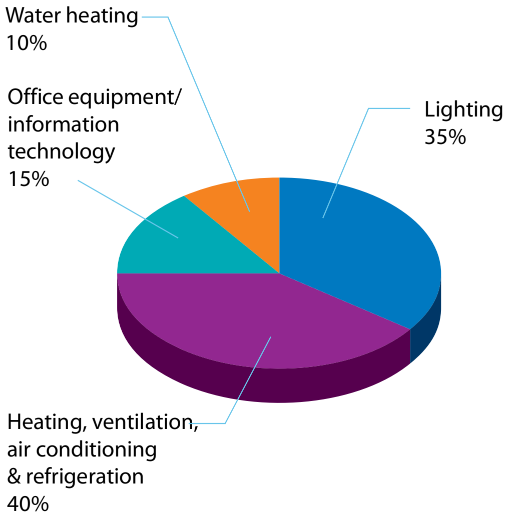


Figure 1 – Typical office energy consumption

2.2.2 Lighting can improve wellbeing and performance

Today's workforce faces far more change than ever before and therefore the challenge for employers is to design work environments that can best meet the needs of 21st century workers and ensure maximum levels of wellbeing as well as performance. The modern office needs more than just good lighting design to cope with these needs, specifiers and designers also need to consider human performance and productivity issues.

Also it is no longer socially acceptable or commercially astute to burn all of the lighting throughout the day and for half the night, yet a feeling of personal security and wellbeing must be protected.

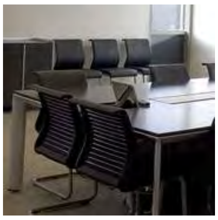
2.3 Philips LightMaster Solutions

Reception

Create a memorable first impression. Put guests at ease. Communicate the corporate culture.

Corridors and stairways

Promote safety.
Save energy.
Accent displays.

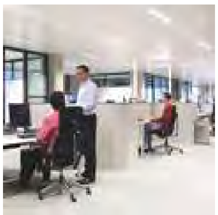


Conference rooms

Design for visual comfort and maximum flexibility: presentations, collaboration and communication. Relax or stimulate as appropriate.

Outdoor and parking

Convey corporate image through attractive lighting and signage. Promote safety. Efficiency and easy maintenance.



Open offices

Facilitate communication. Reduce glare. Engage employees in the corporate culture.

Touchdown areas

Enable social contact and individual short-term work.

Private offices

Flexible. Customizable.
Enable comfort and well-being.

Classrooms and training rooms

Improve concentration and comprehension. Visual comfort. Adaptable for different activities.

2.4 Benefits of Philips LightMaster

Philips LightMaster maximizes energy efficiency and comfort with traditional occupancy sensing and daylight harvesting strategies, but also introduces a range of new strategies for increased flexibility, user comfort and security. The Philips LightMaster networked automation system can automatically dim or switch all lights, access hundreds of preset scenes, perform sequential and conditional tasks and integrate with third party systems.

Philips LightMaster provides the following key benefits:

	Benefit	Feature
Energy Savings - *The right light at the right time and place*		
	Make use of Sunlight	*Daylight regulation*
	Lights on only when needed	*Occupancy control, Smart scheduling*
	Right light level	*Task tuning, Daylight regulation*
	Flexible energy use	*Load shedding*
Flexibility - *Be ready for now and the future*		
	Reduced cost of flexibility	*Manage your layout changes via software*
	Monitor system health	*Monitor (almost) failures*
	One user interface	*Control of all ambient elements from one interface*
	Measure and control	*Full insight in operation, energy usage and management*
Comfort - *Create the perfect environment for tasks and scenes*		
	Optimal light for task/scene	*Personal control, Dynamic (color) control*
	User in control	*Personal control*
	Comfort and safety	*Corridor linking, Open plan background lighting, Integration with blinds*

The Philips LightMaster range has been developed to ensure easy integration into today's modern office environment, for either retrofit or new installations by maximizing the effectiveness of KNX and DALI. This enables greater flexibility so installations can benefit from the best of both of these systems.

The Philips LightMaster office based controls system is fully scalable and suited to both large and small installations. Installations can include:

- Group Control - to locally set the right amount of light at the right time
- Multi Group Control - to provide control over a group of light points and the possibility to provide monitoring of every group of light points
- Lightpoint Management - to fully control the amount of light at the right place at the right time and provide monitoring of every individual light point

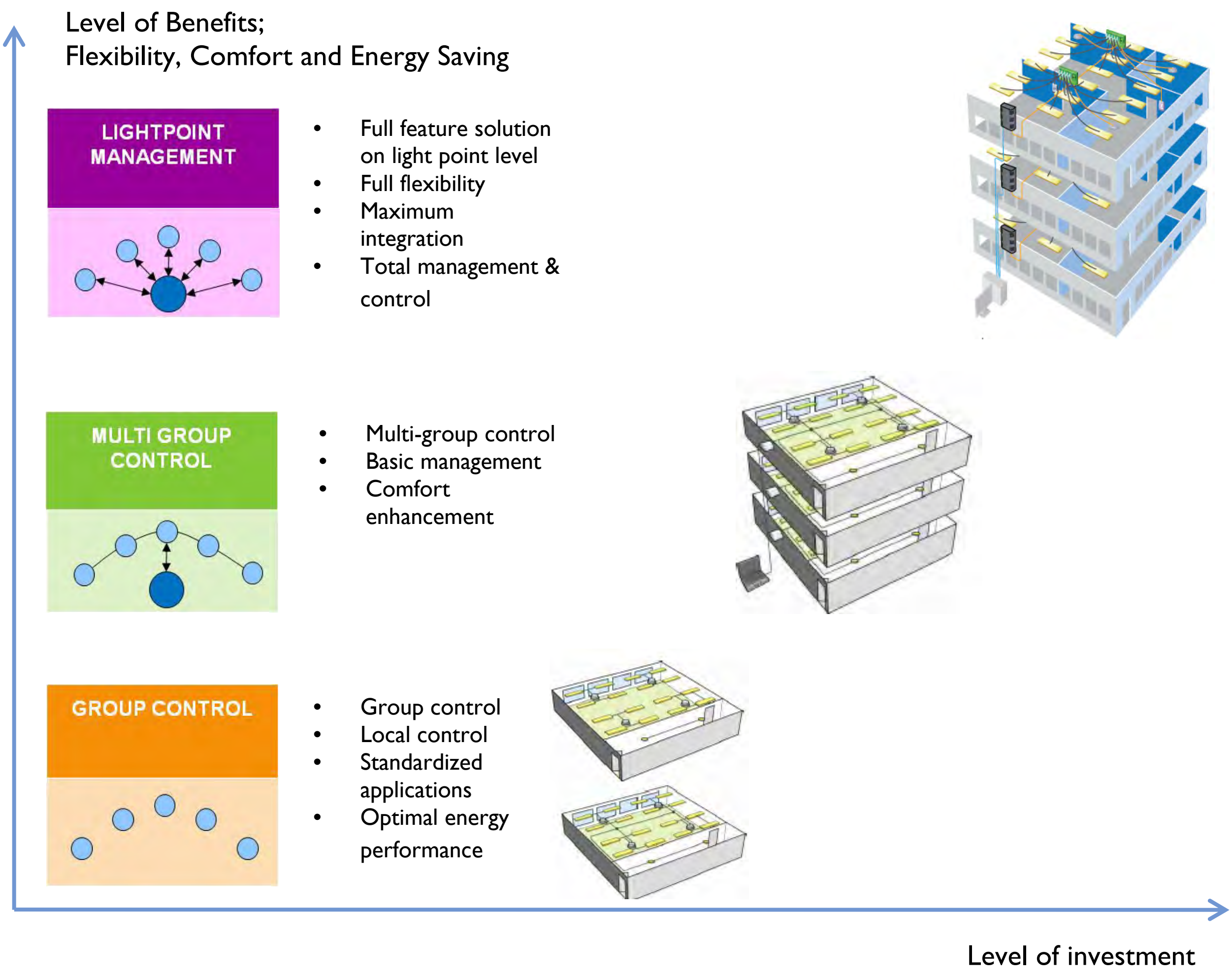


Figure 2 – LightMaster scalability

2.5 Features of Philips LightMaster

LightMaster sets a new benchmark for maximizing comfort whilst minimizing energy use with KNX and DALI. Energy savings are achieved by use of available sunlight penetrating the building and lights are switched on only when needed. Comfort is enhanced, by optimizing the lighting for the task, placing the user in control and supporting a safe well lit environment. The following diagram illustrates how an office floor with controls increases efficiency and effectiveness.

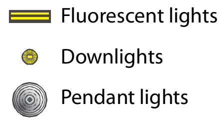


Figure 3 – LightMaster smart building blocks for integration via industry standard interfaces

2.5.1 Fully scalable and robust

"Philips LightMaster control solutions are infinitely scalable and will suit any commercial application"

Multiple KNX network lines can be linked together to form one larger system. A main line and line network topology allows for both scalable and robust network architecture. Many different integration opportunities are available via the KNX standard as well as gateways to third-party systems. With integration, the BMS can trigger timed events and check the current system status.

The introduction to the KNX world of a fully structured cabling solution brings big benefits for all stakeholders in project delivery, installation and operations.

Philips LightMaster load actuators can be used simultaneously on the same KNX network to control other types of lighting with options including: DALI Addressable, DALI Broadcast, DSI and 1-10V for other styles of dimmable lamps and window blind control and relay actuators for any type of switch load.

2.5.2 Intelligent network connections

All Philips LightMaster range network devices are connected together using the industry standard KNX approach. This allows all the LightMaster devices to pass messages between each other on the KNX network as well as onto the DALI network via the DALI load actuators. User interface panels, including third-party devices can be connected via the LightMaster KNX and DALI Dry Contact Interfaces to directly change the current lighting control settings. The DALI MultiMaster solution reduces field installation costs by having sensors and dry contact user interfaces available on the DALI network.

2.5.3 Ultimate control from a single panel

From any one lighting control panel an end-user can take control of the whole system if required. This can be useful for turning off all the lighting at the end of the day. Sensors will automatically adjust the lighting depending on detected motion or the current measured light level. A sensor can not only control its own logical area but also pass messages onto adjacent areas holding on corridor lighting or taking light level measurement for multiple logical area control. In developing the LightMaster range Philips have a range of products that utilize not only the KNX network, but also the DALI lighting control network to communicate between user interfaces such as sensors and pushbutton panels. This not only reduces the system complexities but can also cut the required network field wiring by more than half.

2.5.4 Feature Table

Occupancy Control Feature	Description	Energy Saving	Flexibility	Comfort
Delay Timer	When no movement is detected, this feature first dims the lights to a background level for a set time period to notify that the lights will soon switch OFF, and then switch all lights OFF after another timeout period.	●		
Step Over Pattern	Will activate or maintain desired light levels in multiple areas adjacent to where occupancy has been detected. This feature offers flexibility in setting up lighting behavior in corridors, large open office areas and public areas where areas may overlap. The feature also assists in creating a sense of security and wellbeing for occupants after hours.	●	●	●
Background Level for Open Plan	Also known as adjacent area standby, this feature is used in larger areas equipped with multiple sensors (e.g. modern open plan offices). It can activate or maintain a background lighting level in an open plan office while at least one of the work islands is still occupied. When the last work island area becomes unoccupied, the lights in the open plan will switch off (with a delay). Additionally, this feature can enable tuning of the area to provide a balance between occupancy comfort and energy savings. An example of this is by fully illuminating the occupied areas whilst dimming the light to a standby level in adjacent unoccupied areas.	●		●
Corridor Hold-on	Links areas like offices, meeting rooms or classrooms to a corridor (exit path). Makes certain that the corridor is switched on if one of the areas is still in use. Furthermore, it can dim the lights in the corridor when it is unoccupied if people are still present in the neighboring rooms, for a perfect balance between safety and energy savings	●		●
Cascaded Corridor Hold-on	The exit path lighting can be cascaded, to create multiple dependencies. This feature will allow cell offices to keep corridors lit, corridors to keep lift/lobbies lit, lift/lobbies to keep reception area's lit, etc.	●		●
Light Level Control Feature	**Description**			
Switching	Ability to switch the lights ON and OFF from a flexible choice of networked devices.	●		●
Dimming	Ability to dim the lights from a flexible choice of networked devices. This can be achieved by a protocol (or signal) to a lamp driver (DALI addressable, DALI Broadcast, DSI, or 1-10V). It can also be achieved by power control or phase control dimmers.	●	●	●
Scene Setting **Task Tuning**	One of the most efficient methods of saving energy is to provide only the level of light that is required for the task at hand. This is achieved by enabling a 'scene' for a particular task and can significantly improve the personal comfort of the occupant. Examples of this would include scenes enabled in a meeting room for presentation, meeting or discussion situations.	●	●	●
Daylight Harvesting **Maintained Illuminance**	Through the use of light level detection, this feature adjusts the level of artificial lighting required at any given time, especially in areas that experience high levels of daylight i.e. adjacent to window.	●		●
Corridor-Row Offset	Zones adjacent to windows receive more daylight than those closer to the core of the building including corridors in open space offices. This feature enables the luminaires in the window areas and the core areas to be defined by a ratio. The window area luminaires are dimmed to a lower level than the luminaires in corridor or core areas. The area in-between is dimmed to a pre-defined percentage considering both window and core area levels. This function is identified as corridor row offset.	●		●

		Energy Saving	Flexibility	Comfort
Personal Control Feature	**Description**			
Manual Light Control	In many situations building occupants may not wish to rely on the automatic daylight harvesting function as the available daylight or illumination levels present will suffice. Having manual light level control enables the occupant to switch or adjust the lighting level to their personal preference or return to automated control when desired.		●	●
Panels/Switches	The obvious way of providing personnel or local control is via the provision of switch panels at the point of entry into areas or zones. Allowing the occupant to decide to turn on the lights or not when they enter the area is a simple energy management practice. If the lights are turned on, then the system will still turn off the lights after they leave following a predetermined time-out period.		●	●
Time Control Scheduling Feature	**Description**			
Time Control/ Scheduling	Many lighting functions are time of day dependant for example, the level of light required for office cleaning or during a security scan walk-through, is considerably lower than that required during normal office hours. Scheduling allows lights to be switched ON, OFF, dimmed or behave differently according to a specific schedule. This can be adjusted for weekends, public holidays or other shut down periods. Requires KNX timers that are available from many third party vendors.	●	●	
Specialised Control Feature	**Description**			
Load Shedding	This function allows some or all luminaires to dim or switch off when the buildings energy consumption is in excess of predefined limits. This maximum limit can be static or dynamically set, possibly by the energy provider. When configured correctly, security, personal safety and comfort are maintained at the highest levels possible. This function is implemented, through a dry contact interface integrated via the KNX network.	●		
Emergency Linking	Makes it possible to link various systems, e.g. fire and security, to the lighting system so as to ensure lighting is switched on during emergencies. This function is implemented, through a dry contact interface integrated via the KNX network		●	●

2.6LightMaster Technology

The Philips LightMaster range takes both the KNX and DALI open communication protocols and by adding their acknowledged controls and lighting expertise, are able to get a better result for all stakeholders in the office, hospitality and retail segments over what is available in the market today. Additional flexibility is available through both DIN rail and structured cabling solutions. LightMaster uses the latest developments in the DALI MultiMaster approach – where user interfaces as well as lighting ballasts are available on the DALI bus and now provides the KNX world with these additional design and installation benefits.

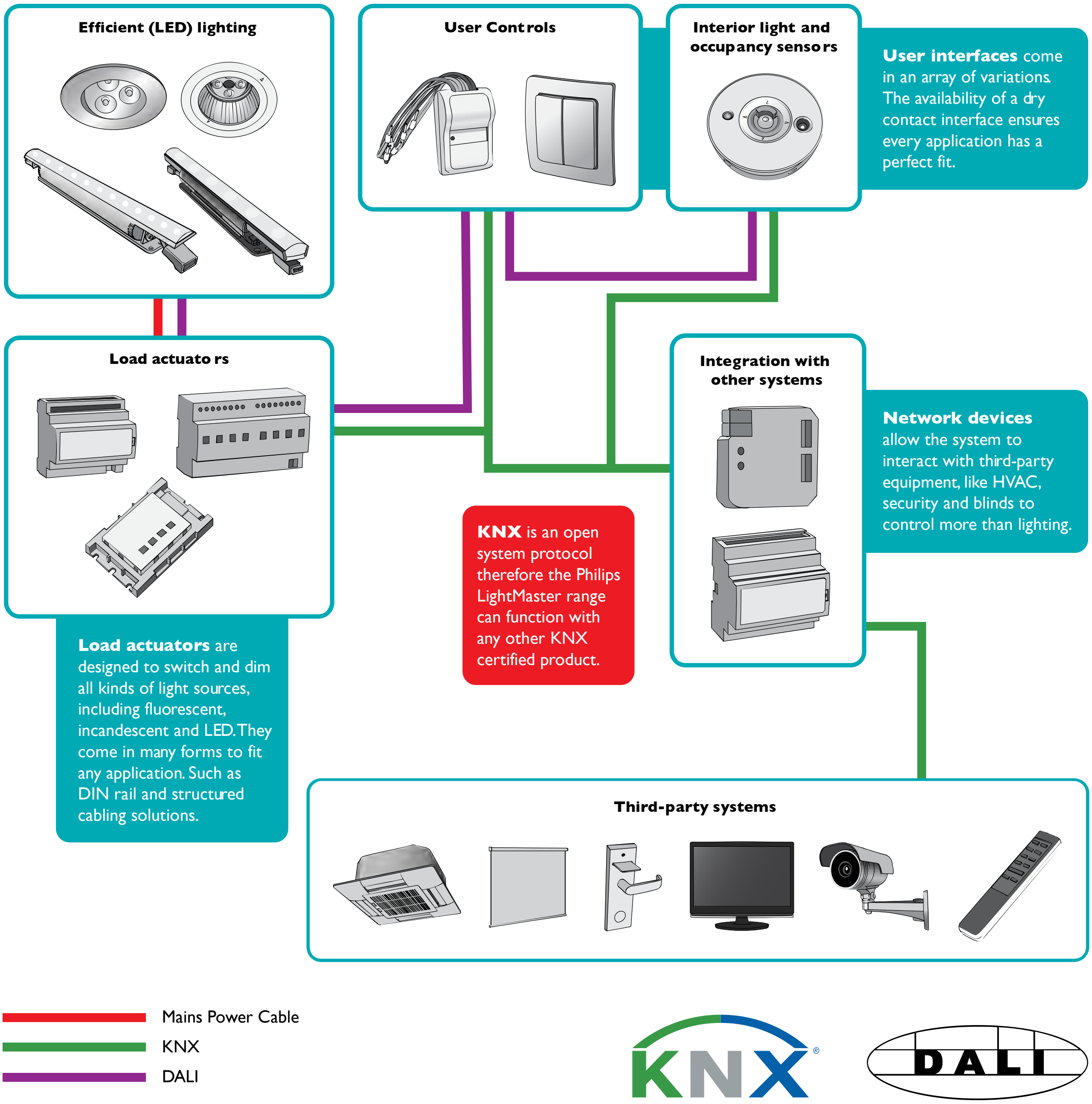


Figure 4 – LightMaster Technology

2.6.1 KNX

KNX (previously known as EIB) is an open standard protocol for intelligent buildings developed in Europe in the late 20th century. The KNX standard is supported by a large network of qualified contractors, planners, integrators and manufacturers around the world.

In KNX, the words Actuator and Sensor are used in a general sense. An Actuator is any device that receives information from the network to perform an action and a Sensor is any device that senses an action and sends the information to the network.

Advantages:

- KNX interoperability is standardized for all devices. All KNX devices can be connected to form a functional installation thanks to the standardization of telegrams (messages) that are sent between devices.
- KNX is designed to be independent of any particular hardware platform. This means there is a wide range of available off-the-shelf components.
- KNX devices can be assigned to multiple groups enabling flexible commissioning.
- KNX can operate over several physical communications media such as twisted pair (TP) wiring, power line (PL), radio (RF), Ethernet (IP). Twisted pair wiring is most commonly used.

Disadvantages:

- The control cable supplies energy and control signals for devices over two wires with additional power supplies required for each line segment and polarity being critical.
- ETS (Engineering Tool Software) although standardized, is mandatory; extra functionality and advanced functions are configured using proprietary plug-ins.
- The Individual address for each device can only be downloaded one by one by physically pressing the programming button on each device.

2.6.2 DALI

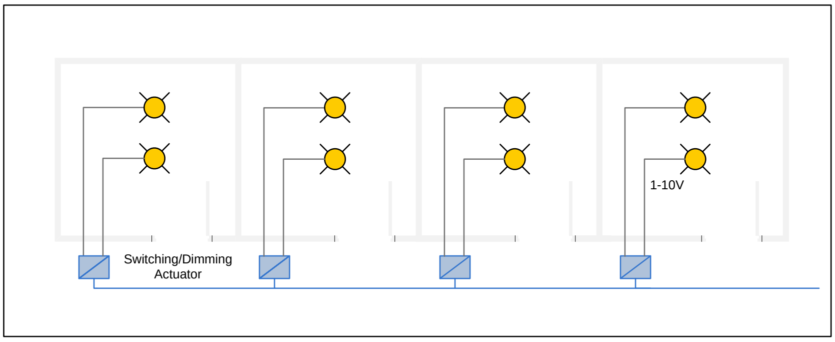
The DALI standard is known as IEC62386. The DALI standard encompasses the communications protocol and electrical interface for lighting control networks. Instead of just regulating the power, DALI systems communicate directly with lighting ballasts.
Being digital, DALI can be used to create intelligent lighting systems that provide increased energy savings, easier installation and maintenance, with maximum control and retrofit flexibility.

DALI was established as an open communication successor to the Digital Serial Interface (DSI) and 1-10 V lighting control systems. DALI devices include fluorescent HF ballasts, low voltage transformers, LEDs, light sensors, motion detectors, wall switches and gateways to other protocols. There can be up to 64 DALI devices on a single DALI network. This is called a DALI universe.

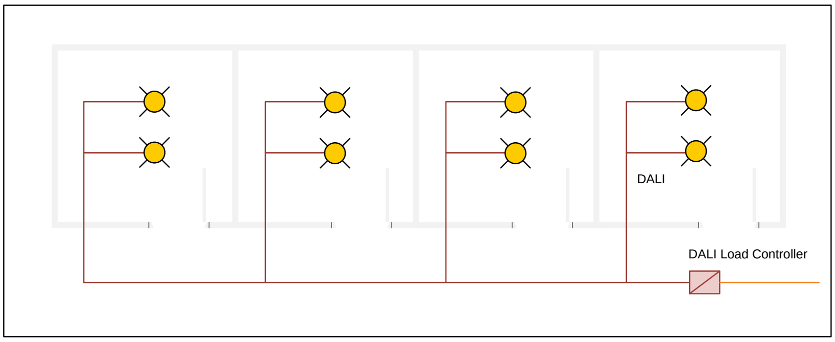
Advantages:

- can provide feedback on status.
- can be addressed separately or as part of a group
- can all be contacted at the same time by way of a broadcast.
- can connect other devices with MultiMaster control

In contrast, DSI and 1-10V devices are not separately addressable and are controlled based on hardwired groups. The net result is that to achieve similar control functionally, DALI requires less complex (and therefore less expensive) wiring topology than DSI or 1-10V analogue devices.



1-10V solution: At least one 2-way switching/dimming actuator is needed per room



DALI solution: More functions – fewer components.
With just two wires at the output, the interface has the same functionality as 16 switching/dimming actuators. This means that a single unit can be used to form up to 16 groups which can then be easily changed using software – there is no need to do anything with the wiring.

Figure 5 – DALI Network

Disadvantages

- DALI has a relatively slow baud rate of 1200 baud that results in obvious delay when individually addressing large numbers of ballasts creating a Mexican wave effect. However this can be avoided by using DALI group addressing and/or DALI broadcast addressing.

- DALI ballasts and devices require enumeration to create a DALI address. Re-enumeration must be performed when replacing a ballast or device.

- The DALI protocol does not allow for communication between different universes. However, sites requiring more than 64 devices are implemented by having multiple separate DALI universes. These separate networks are then linked together with DALI gateways and a data backbone running another protocol such as KNX.

Caution: The control cable MUST be mains rated. The usage of low voltage cable is NOT allowed since the connected ballasts are not double insulated but only have basic insulation towards the mains.

Tip: When implementing DALI, the built in features of Philips LightMaster equipment provides the following benefits:

- Light Control Actuators also act as DALI Gateways
- DALI Enumeration performed by actuator
- ETS Plug-in for configuring lighting areas
- DALI feedback for lamps and ballast status, emergency testing/logging
- Integrated:
    - DALI power supply
    - DALI transmitter
    - DALI scene controllers
    - power relays per DALI universe (to provide true off)
- Reduced wiring with MultiMaster devices on the DALI network
- Presets scenes send group messages to DALI ballasts eliminating Mexican wave
- DALI controllers have a built in test sequence to identify any faulty wiring or ballasts prior to commencement of commissioning
- No system network clock or network burden
- No single point of failure
- Easy serviceability
- Ballast replacement is simplified with software plug-in

2.6.3 DSI

Digital Serial Interface (DSI) is a protocol for the controlling of lighting in buildings (initially electronic ballasts). It was created in 1991 and is based on Manchester-coded 8-bit protocol, data rate of 1200 baud, 1 start bit, 8 data bits (dimming value), 4 stop bits, and is the basis of the more sophisticated protocol Digital Addressable Lighting Interface (DALI).

The technology uses a single byte to communicate the lighting level (0-255 or 0x00-0xFF). DSI was the start of digital ballast communication technology and was the precursor to DALI.

Advantages

- DSI's simple nature makes it straightforward to understand, implement, and diagnose, while its low voltage means it typically runs along relatively thin cables.
- As each device has its own wire to the controller (rather than being part of a network) it has no need of an address to be set, so can be replaced simply by unplugging the faulty one and plugging in the new.
- The system costs involved in the systems requiring individual lamp control can be much higher than a DALI system.

Disadvantages

- It requires one wire per control channel so a sophisticated system could have hundreds of wires, making diagnoses of problems difficult.

Caution: The control cable MUST be mains rated. The usage of low voltage cable is NOT allowed since the connected ballasts are not double insulated but only have basic insulation towards the mains.

2.6.4 1-10V

1-10V is one of the earliest and simplest electronic lighting control signaling systems; simply put, the control signal is a DC voltage that varies between one and ten volts. The controlled lighting should scale its output so that at 10V, the controlled light should be at 100% of its potential output. Dimming devices may be designed to respond in various patterns to the intermediate voltages, giving output curves that are very linear for: voltage output, actual light output, power output, or perceived light output.

Advantages

- It is straight forward and simple to understand, implement and diagnose while its low current (min and max value of 10uA and 2mA respectively) means it can be run along relatively thin cables with little voltage drop.
- Very good for color mixing.

Disadvantages

- It requires one wire per control channel (plus a common return wire). A sophisticated system could have hundreds of wires, requiring expensive multicore cables and connectors.
- Need a relay channel to switch off because it cannot be sent to 0% output.
- Over a long cable, the voltage drop requires every channel of the receiving device to be calibrated to compensate for the voltage losses. However this is only a theoretical limitation as the resistance of the thinnest practical wire is around 20Ω / 1000m.

Caution: The control cable MUST be mains rated. The usage of low voltage cable is NOT allowed since the connected ballasts are not double insulated but only have basic insulation towards the mains.

The quantity of ballasts is determined by the sink/source of the ballast. Multiply the sink/source by the quantity of ballasts and cross reference with the 1-10V Controller data sheet.

2.7User Interfaces

Providing end-users with an intuitive means of interaction with the lighting system, Philips LightMaster user interfaces includes wall panels and universal sensors.

2.7.1 Button Panels

A local control panel allows occupants to adjust the lighting control system to suit their requirements. To help perform the various functions required of the control system and help users to intuitively interact with the many different features, each panel is powered directly from the network and therefore requires no mains wiring. Panels can be individually configured via the KNX industry standard ETS commissioning software to perform simple or complex logical functions. Philips LightMaster panels bring the full power of the control system to the single touch of a button. One button press can instantly change the look and feel of the whole environment.

2.7.2 Sensors

Offering the ability to interact with project spaces passively, the Philips LightMaster sensor range brings the features of motion detection and light level detection into one unit, in a compact and aesthetic solution. Each of the features can be operating at the same time, allowing automation scenarios such as turning on the lights after detecting motion and then dimming the lighting level once the available sunlight has been measured, providing additional energy savings. After the area has been unoccupied for the predetermined time, the lights will then switch off. Combining each of these functions into the one device reduces the need for many different types of sensors cluttering the ceiling space.

Each sensor has an inbuilt microprocessor, allowing for logical functions to control a small room, the floor of a building or an entire building. All sensors receive their power from the KNX or DALI network and as they are fully remotely programmable, they can be configured to automate and control virtually an unlimited number of controlled outputs.

2.8 Load Actuators

The heart of the automation system, the Philips LightMaster range of load actuators directly drive all the different lighting groups within a project and allow the system to be compatible with any lamp type and lighting control protocol. Philips LightMaster load actuators are the ideal choice for combining feature rich lighting control requirements with superior build quality to continuously perform problem free.

All load actuators support the KNX industry-standard ETS software to communicate with other devices on the KNX network. Other third-party devices can use this same network to communicate with the LightMaster devices. A combination of load actuator devices can be selected to work seamlessly together to achieve common project design goals.

2.8.1 Relay Actuators

As one of the most popular forms of lighting control, relay actuators can provide the most impact to energy management and lighting control. Available in DIN rail configuration, Philips LightMaster supports a range of relay controllers with a variety of circuit numbers to work individually or as part of a system, suiting any project requirement.

Each device can store over a hundred preset scenes, allowing the recall of complex switching logic from simple network messages. As the required preset scenes are stored within each relay device, the commissioning process and network messages are simplified

2.8.2 Dimmer Actuators

The Philips LightMaster range of Open Protocol Dimmer Actuators, have been engineered to meet the future demands of projects. They are capable of transmitting all industry standard ballast protocols (DALI addressable, DALI broadcast, DSI and 1-10V), and support two ranges of install opportunities of both DIN rail and structured cabling, to allow for flexible install opportunities. The Open Protocol Dimmer Actuator range also supports a variety of output circuit combinations, suiting any project requirement.

Each device can store over a hundred preset scenes, allowing the recall of complex switching logic from simple network messages. As the required preset scenes are stored within each relay device, the commissioning process and network messages are simplified.

2.9 Network Devices

2.9.1 Dry Contact Interfaces (DCIs)

Philips LightMaster DCI's are designed to allow mechanical switches and relays to interface to the KNX network. The function of each input is programmable and the small size of the product combined with the inputs being presented makes it perfect for installation behind multi-gang switch grids. In addition to being used as a simple dry contact interface, these DCI's have a 'motion detector' mode that turns a third-party motion detector into a fully featured KNX sensor.

2.9.2 Line Coupler

The Philips LightMaster line coupler can be used to link a line to a second line in order to extend the network or it can be used to link a line to a main line (or backbone). In this respect it provides electrical isolation and message (telegram) filtering.

2.9.3 Network Power Supply

The Philips LightMaster KNX power supply provides the installed bus components with energy and to ensure robust and reliable bus communications. The power supply is usable Worldwide with a wide range of supply voltages. It has an LED indicator for Power, Overload and Reset. There is a push button for automatic reset on the KNX line and commissioning is not required.

3 Hardware Overview

The LightMaster system uses distributed intelligence. This means that no single point of failure can affect the whole system. Each individual LightMaster device both broadcasts and responds to messages on the network. This ‘Broadcast Network’ communication principle provides the necessary flexibility to ensure that a system can be easily (and at low cost) altered or added to after installation. It is possible to add extra equipment at any time without the need to re-configure or rewire any part of the existing system.

A key principle of LightMaster is that all functions associated with a particular device are located within that device. For example, all scene preset information is stored within the actuators. This means that if any device should fail, only the functions associated with that device are lost, other devices on the network are not affected. From a maintenance point of view, this concept of distributed control (self-contained) units both speeds up fault-finding, and allows a high level of fault tolerance in large systems.

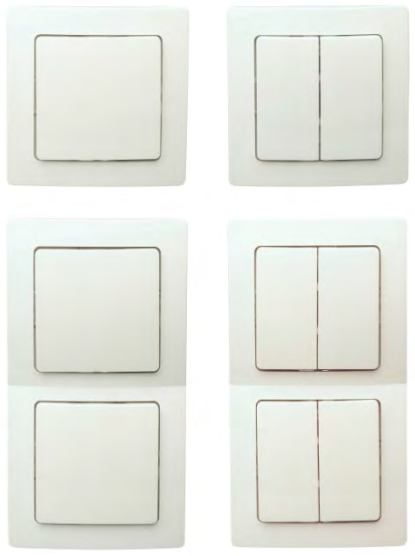
3.1 Product Table

The table below lists the current range of Philips LightMaster products.

User Interfaces	Networking Devices	Load Actuators
P1PE-KNX-2P P1PE-KNX-4P LightMaster Switch Range	PLC-KNX LightMaster Line Coupler	PDRC416FR-KNX LightMaster Relay Actuator (4 x 16A)
PLOS-CM-KNX LightMaster Multifunction Sensor	PPS640-KNX LightMaster Network Power Supply (640ma)	PDRC816FR-KNX LightMaster Relay Actuator (8 x 16A)
PLOS-CM-DALI LightMaster Multifunction Sensor	PPMI4-KNX LightMaster Dry Contact Interface	PDRC1216FR-KNX LightMaster Relay Actuator (12 x 16A)
	PPMI4-DALI LightMaster Dry Contact Interface	PDBC120-DALI-KNX LightMaster DALI MultiMaster Dimmer Controller (64 DALI channels + 10 MultiMaster devices)
		PDLPC416FR-KNX LightMaster Dimmer Actuator (4 x 16A)
		PLPC905GL-3-KNX PLPC905GL-3-HD-KNX PLPC905GL-4-KNX PLPC905GL-4-HD-KNX LightMaster Structured Cabling Dimmer Actuator (9 x 5A)

3.2User Interfaces

3.2.1 Light Master Switch Range PIPE-KNX-2P PIPE-KNX-4P



Contemporary design and smart operation are just two factors integrated into the LightMaster P1PE-KNX-2P & 4P switch panel range. With a very flexible base module component, both specifiers and installers get more functionality to control complex functions in all types of commercial buildings. Straight switching as well as multifunction combinations including dimming, blind and scene control can all be achieved. All of these factors add up to provide maximum comfort for users as well as minimum energy management possibilities for building operators and owners. Available in 2 position and 4 position options with engraving opportunities available on a project basis.

3.2.2 LightMaster Multifunction Sensors PLOS-CM-KNX, PLOS-CM-DALI

The PLOS-CM-KNX & PLOS-CM-DALI are low profile recessed flush mount 360° ceiling mount sensors that combine PIR motion detection and PE ambient light level detection – in the one device. In applications such as office buildings these universal sensors can be used to detect motion and switch on the lights or a preset lighting scene. When rooms are unoccupied, lights can be automatically dimmed or switched off to provide energy savings. These units also incorporate a segmented click-up bezel surrounding the motion sensor element. This enables a portion of the sensing field to be readily masked to prevent nuisance detection from adjacent doorways or corridors. In situations where it is critical to maintain precise lighting control for individual workspaces, such as an office workstation, the sensors facilitate maintained illuminance and daylight harvesting.

The PLOS-CM-KNX is powered directly by the KNX network. The PLOS-CM-DALI is powered directly by the DALI network that is running between the DALI light fittings, thus eliminating the need for additional network field wiring.

Note: The PLOS-CM-DALI sensor can only be used when connected to a Philips LightMaster DALI Multi-Master controller.

3.3 Networking Accessories

3.3.1 Dry Contact Interfaces PPMI4-DALI, PPMI4-KNXI

Each device is a four-input dry contact interface, designed to allow mechanical and electronic switches to interface directly with the KNX or DALI MultiMaster networks. They can be used as a simple dry contact interface for low level integration to third-party systems such as security and air conditioning so that the lighting can be coordinated together with other services found within a project. The function of each input is programmable and the small size of the product makes it perfect for installation within a wall box.

Note: The PMI4-DALI dry contact interface can only be used when connected to a Philips LightMaster DALI MultiMaster Controller.

The PPMI4-KNX is powered directly by the KNX network. The PMI4-DALI is powered directly by the DALI MultiMaster network that runs between the DALI light fittings, thus eliminating the need for additional network field wiring.

Caution: Although the voltage on the DALI wires is low (typical 16V), the system is only provided with basic isolation. Therefore the DALI control wires must be treated as mains wires. Any mains-voltage rated wire or cable can be used).

3.3.2 LightMaster Line Coupler PLC-KNX

The Philips PLC-KNX is designed for cost-effective optical isolation of KNX networks. The two opto-isolated KNX ports enable the PLC-KNX to implement a main line and line topology, with each line being electrically isolated from the others so a fault in one section of the network will be contained. It is a 'passive' device that does not require programming.

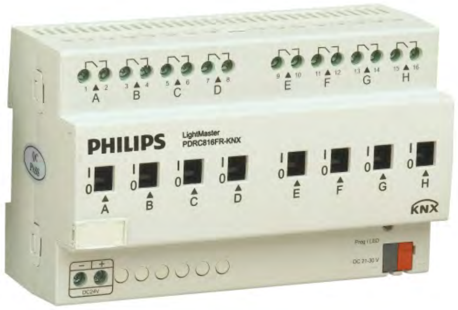
3.3.3 LightMaster Network Power Supply PPS640-KNX

The PPS640-KNX is a regulated power supply with an integrated Bus choke, designed to provide network DC supply to the KNX network. The switchmode design allows the device to be used with a wide range of supply voltages without the need for a manual selector setting. The PPS640-KNX is housed in a 6 unit DIN rail mount enclosure that has a circuit breaker profile. This enables the device to be installed in all types of electrical equipment enclosures, including those with cover apertures specifically designed for circuit breakers.

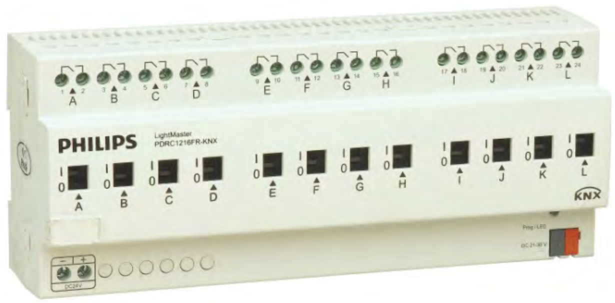
3.4 Actuators

3.4.1 LightMaster Relay Actuators PDRC416FR-KNX, PDRC816FR-KNX PDRC1216FR-KNX

These relay actuators are designed to control any type of switched load and are available in 4, 8 & 12 pole configuration. The power circuit is of a ‘feed through’ design and is electrically equivalent to a 4, 8 or 12 pole contactor, with the additional advantage of each pole being separately controllable via the KNX network.



The relay actuators are DIN rail mountable, designed to be installed in a switchboard next to the circuit breakers feeding the circuits to be controlled. Each channel is fitted with a hardware override switch which is accessible from the front panel.



The LightMaster relay actuator range generally does not require an additional power supply unless synchronous switching of several channels is necessary.

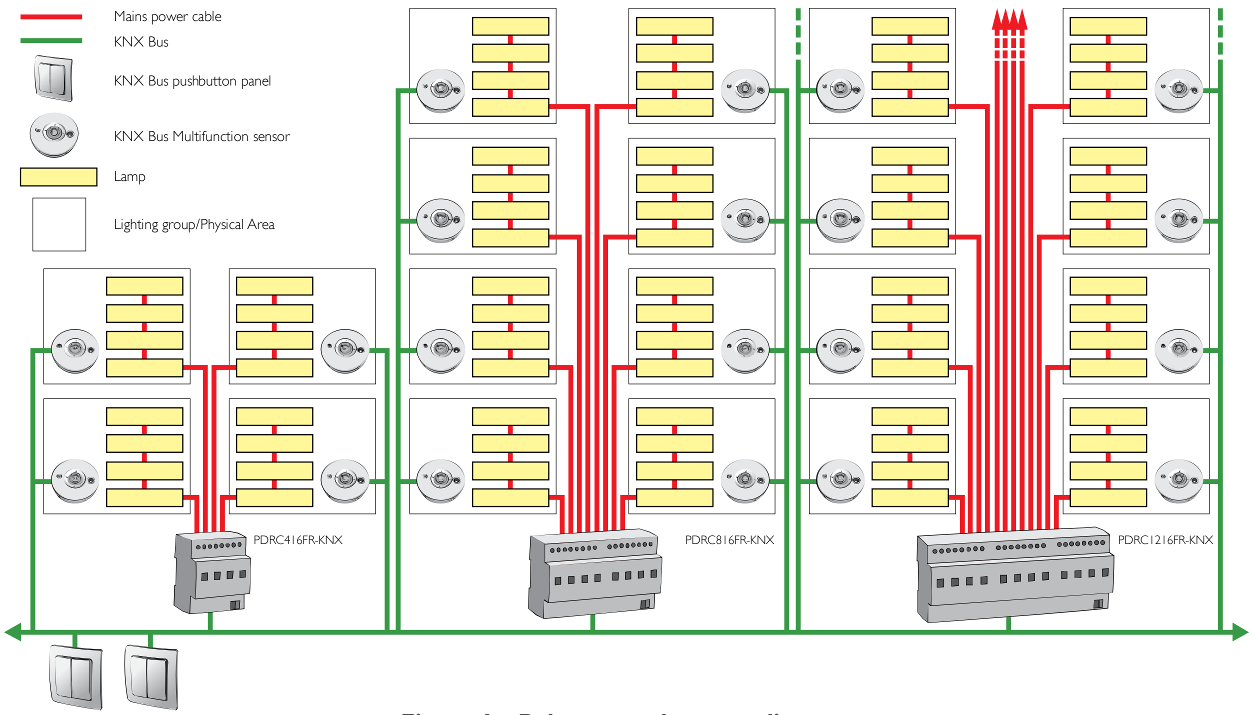


Figure 6 – Relay control system diagram

3.4.2 LightMaster Structured Cabling Dimmer Actuator PLPC905GL-3-KNX, PLPC905GL-3-HD-KNX, PLPC905GL-4-KNX, PLPC905GL-4-HD-KNX

These devices are standard protocol dimmer actuators designed for direct installation within ceiling cavities with power and communications connections via a structured cabling solution. Each control output supports DALI broadcast, DALI addressed, 1-10V and DSI protocols. For ease of installation and maintenance the device incorporates structured wiring connectors, which enables the unit to be readily connected without the use of tools.

The device can be readily integrated with a Building Management System (BMS) via the KNX control network, making it ideally suited to commercial installations where a cost-effective control solution is required. The device design provides easy connection without the use of tools and is available for 3 or 4 pole Wieland power wiring and 2 pole communication wiring systems. It is also available with optional HD – Heavy Duty relays for applications where high inrush currents occur.

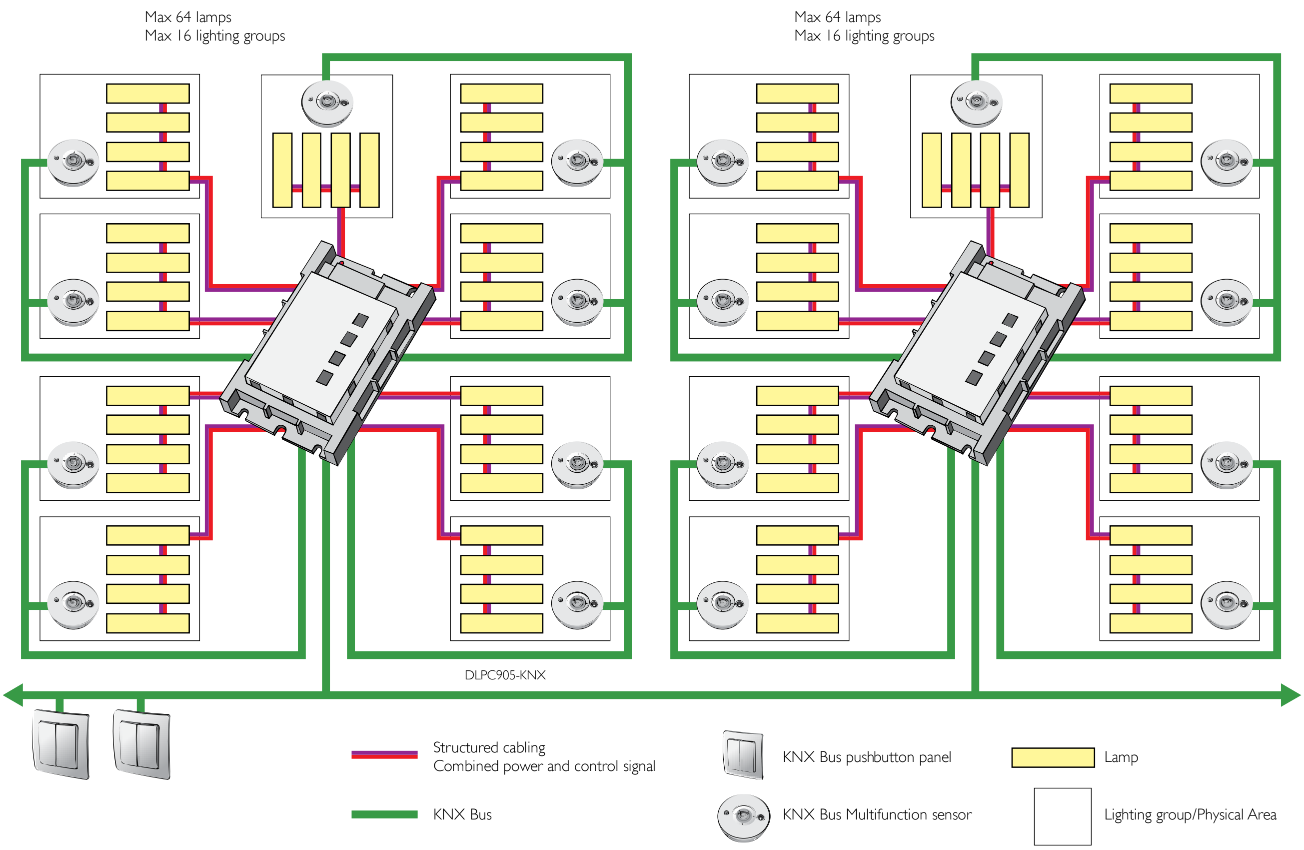


Figure 7 – Light control structured cabling system diagram

3.4.3 LightMaster Dimmer Actuator PDLPC416FR-KNX

This device is a standard protocol dimmer actuator designed to provide cost-effective control of dimmable luminaires. Each of the four control outputs support DALI broadcast, DALI Addressed, 1-10V and DSI protocols. The control signals can be programmed to operate in tandem with the four internal switched outputs, which will automatically isolate the power circuit when all associated channels are at 0%. This feature is useful for energy savings applications, as DALI ballasts draw a significant amount of power when the lamps are turned off via a DALI command.

The device is DIN rail mountable, designed to be installed in a switchboard next to the circuit breakers supplying power to the controlled lighting circuits. The device contains an integral DALI bus power supply, removing the need for the provision of a separate external power supply which reduces costs in both hardware and labor as well as reducing switchboard wiring complexities.

3.4.4 LightMaster DALI MultiMaster Dimmer Actuator PDBC120-DALI-KNX

The DALI MultiMaster Actuator is designed for cost-effective control of DALI compatible lamp drivers, providing a full universe of 64 DALI channels. It provides communication to the KNX network and DALI MultiMaster devices such as sensors and dry contact interfaces. Direct DALI to KNX mapping means that the DALI-imposed limits, such as the maximum of 16 groups, are seamlessly overcome allowing for a fully scalable network solution.

This device is DIN rail mountable, designed to be installed in a switchboard that is supplying power to the controlled lighting circuits. The device contains an integral DALI bus power supply, removing the need for the provision of a separate external power supply which reduces costs in both hardware and labor as well as reducing switchboard wiring complexities.

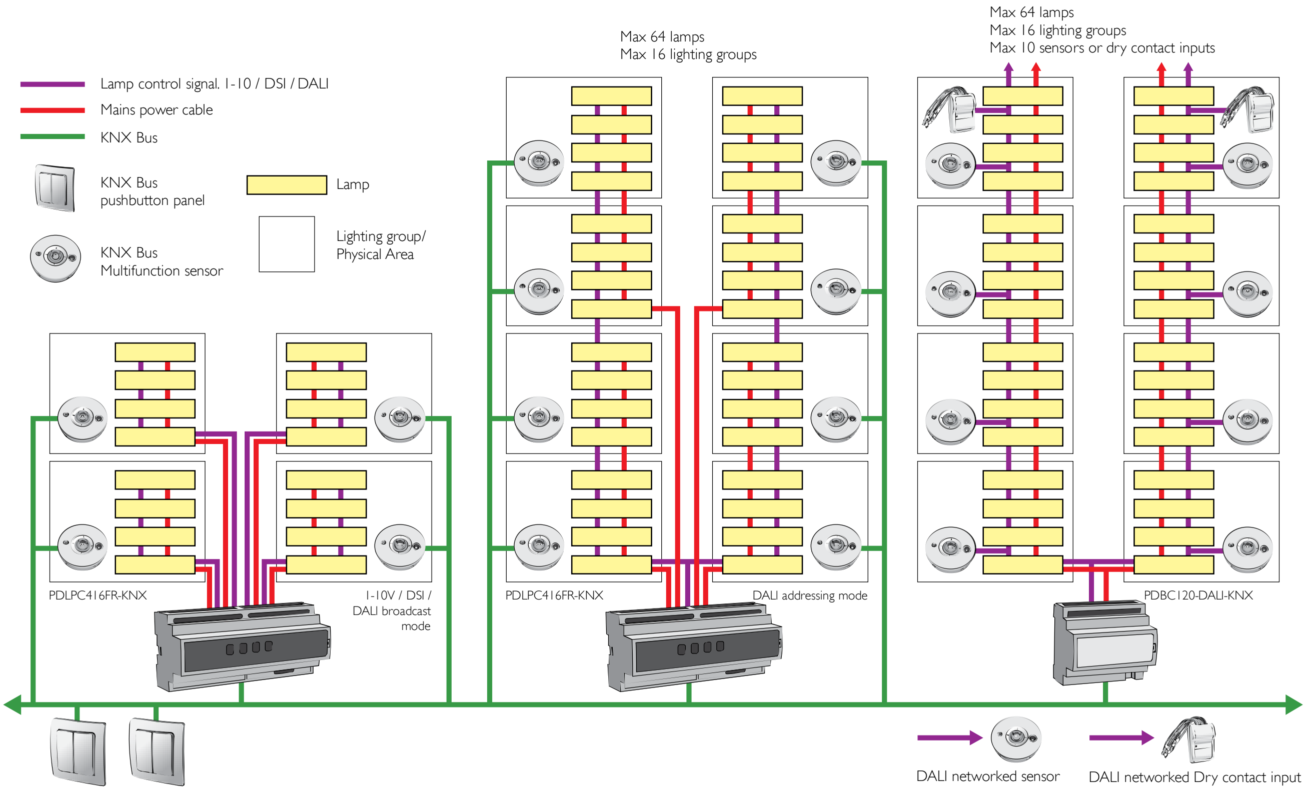


Figure 8 – Dimming control system diagram

4 Ways of Control

Lighting control plays a strategic role in the operation of a modern office environment. It ensures that the visual performance of the lighting equipment is appropriate to the needs of the occupants, while simultaneously conserving energy.

For example, workstations co-exist with traditional enclosed offices in many buildings. They typically share an array of fluorescents overhead while corridors, lobbies, meeting rooms and amenities can have a variety of local lighting types and technologies. By day, illumination levels can be maintained dynamically, both to comply with relevant lighting and energy codes and to ensure optimum worker performance. After hours control is targeted more toward energy conservation, but still accommodates the needs of maintenance and security staff and late night workers.

Appropriate strategies for the lighting controls must be determined according to the specific needs of each application.

4.1 Occupancy Control

4.1.1 Occupancy sensing

Occupancy control is used to detect movement of people in an area by detecting infrared radiation. Occupancy control allows hands-free operation of the lighting, and can help to reduce energy consumption.

To apply occupancy control, an occupancy sensor must be used. The occupancy sensor is a PIR (Passive Infra-Red) sensor that detects occupancy based on movements in an area. Sensors can also incorporate masking shield surrounding the motion sensor element. This enables a portion of the sensing field to be readily masked to prevent nuisance detection from adjacent doorways or corridors.

Occupancy control can also be used in combination with other control functions (such as manual control or daylight harvesting). For more information refer to Combined Control.

Note: The PIR sensor detects movement by means of a temperature difference, for example the human body versus its surrounding temperature. It is recommended not to use the occupancy sensor in outdoor or parking applications, as it will not detect a vehicle just starting its engine, nor does it see people sitting within a vehicle.

4.1.2 Delay Timer

When occupancy control is used, LightMaster can automatically switch the lights ON when an area is occupied and dim the lights or switch them OFF when the area is vacated after a delay. When the area is vacated, the system can be configured to first dim the lights to a background level for a set time period to notify that the lights will soon switch OFF, or immediately switch OFF.

When using occupancy control, a number of delays are used to prevent the lights from switching too frequently if the occupant is sitting still.

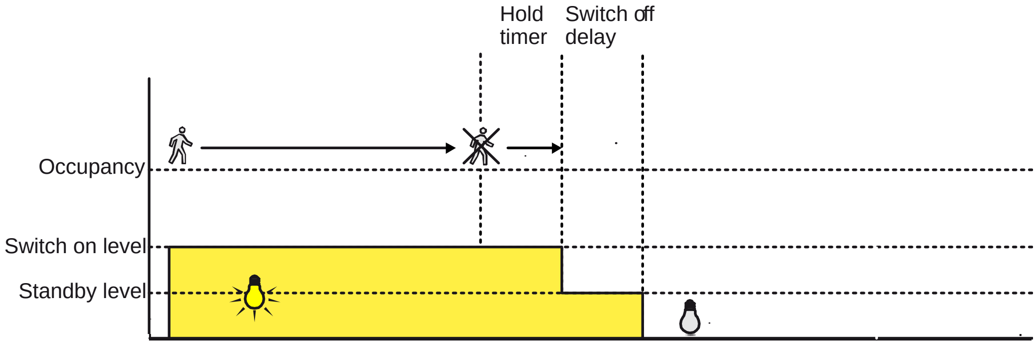


Figure 9 – Delay timer overview

4.1.3 Background Level for Open Plan (Adjacent Area Standby)

Also known as adjacent area standby, this feature is used in larger areas equipped with multiple sensors (e.g. modern open plan offices). It can activate or maintain a background lighting level in an open plan office while at least one of the work islands is still occupied. When the last work island area becomes unoccupied, the lights in the open plan will switch off (with a delay). Additionally, this feature can enable tuning of the area to provide a balance between occupancy comfort and energy savings. An example of this is by fully illuminating the occupied areas whilst dimming the light to a standby level in adjacent unoccupied areas.

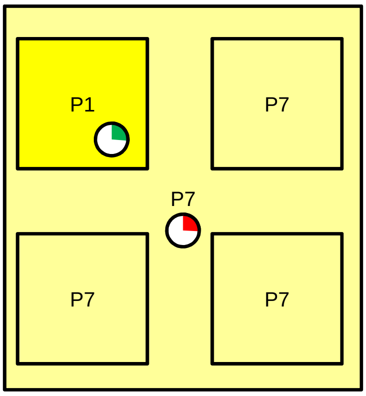


Figure 10 – adjacent areas and background lighting on standby

4.1.4 Step over patterns

Will activate or maintain desired light levels in multiple areas adjacent to where occupancy has been detected. This feature offers flexibility in setting up lighting behavior in corridors, large open office areas and public areas where areas may overlap. The feature also assists in creating a sense of security and wellbeing for occupants after hours.

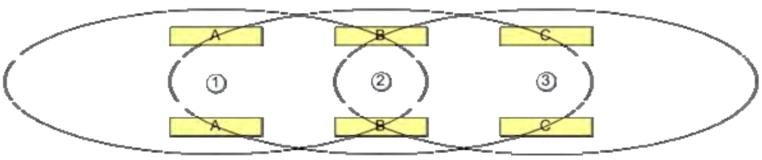


Figure 11 – Step over pattern

4.1.5 Corridor Hold-on

Corridor Hold-on provides the opportunity to make the light level in one area dependent on the occupancy state in another area. This makes it possible, for example, to keep the corridor lights ON if any of the adjacent rooms are still occupied.

When using Corridor Hold-on, all connected areas notify their occupancy state to an area activator and hold timer. The area activator then manages the associated areas (for example the corridor) keeping their lights ON until all associated areas are vacated at which point, after an acceptable exit delay the hold timer will turn OFF all associated corridor and other general lighting.

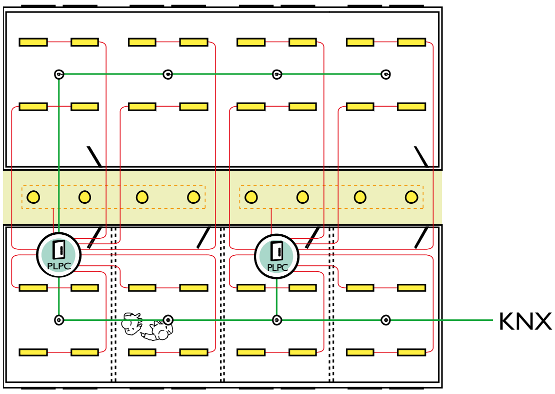


Figure 12 – Corridor Hold-on keeps corridors lights ON

4.2 Light Level Control

4.2.1 Switching

Light level control switching enables the lights to be switched on and off, either manually within an area or using timers or sensors.

4.2.2 Dimming

Dimming is the next most commonly used control after switching. The ability to dim the lights can be achieved by a protocol (or signal) to a lamp driver/ballast (DALI, DSI, DMX or 1-10V).

4.2.3 Scene Setting/Task Tuning

One of the most efficient methods of saving energy is to provide only the level of light that is required for the task at hand. This is achieved by enabling a ‘scene’ or preset for a particular task and can significantly improve the personal comfort of the occupant. Examples of this would include scenes enabled in a meeting room for presentation, meeting or discussion situations. A scene can incorporate one or many channels set to different levels.

4.2.4 Maintained Illuminance

Lighting layouts are generally designed based on luminaires operating at the lowest output state within their service cycle. As lamp efficiency decreases over time and surface dirt builds up on fittings, light output can be dramatically reduced. As a result, luminaires at the start of their service

cycle will emit excess luminance. The energy related to luminance in excess of that required to meet task requirements is wasted.

Maintained Illuminance is a strategy whereby task luminance is measured and the luminaire output is controlled to deliver the exact luminance required for the task. Optimum light output is maintained in the work area. Automatic dimming control enables this to be continuously monitored and smoothly adjusted. Without this, many offices are subject to extremely high light levels from luminaires burning at full power output at the start of the service cycle.

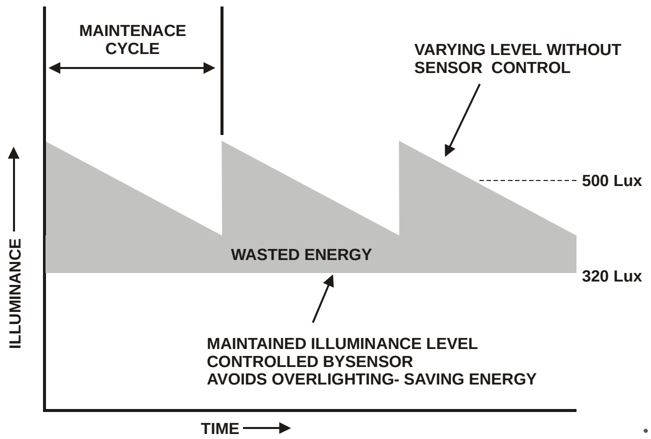


Figure 13 – Maintained Illuminance Cycle

4.2.5 Daylight Harvesting

Daylight harvesting is a control strategy using a PE (Photo-Electric) sensor which measure illuminance. This helps to keep a constant light level in all situations where natural light is available. When there is little or no daylight, the luminaires produce the required light level. When there is enough daylight available, the luminaires may dim or be switched OFF completely.

Daylight control can be used in combination with other control functions, such as manual control or occupancy control. For more information refer to Combined Control.

4.2.5.1 Daylight sensing

To apply daylight control, a daylight sensor must be used. The daylight sensor reads the actual average luminance. The intensity of the luminance depends on the amount of artificial and / or daylight in the room as well as on how well this light is reflected towards the sensor. The light reflection depends highly on the colors and materials chosen to furnish the office.

For accurate measurement and regulation, it is important to calibrate the light sensor. For the procedure to calibrate the daylight sensor refer to the LightMaster Commissioning Guide.

4.2.5.2 Control Modes

There are two types of daylight harvesting each type can be used independently or combined:

- daylight switching
- daylight regulation

4.2.5.3 Daylight switching

Switching is the simplest way of implementing daylight control, and can be used with all lighting types (dimmable and non-dimmable).

When a sufficient amount of daylight enters the room, the luminaires will be switched OFF. The luminaires will be switched ON again when the amount of daylight decreases below the switch-off level. To avoid frequent switching a delay can be used for switch OFF.

Daylight switching is ideal for halls and corridors but also for applications such as outdoor lighting, garages and signposts.

It is not recommended to only use daylight switching in offices, as the changes in light level due to switching are very noticeable.

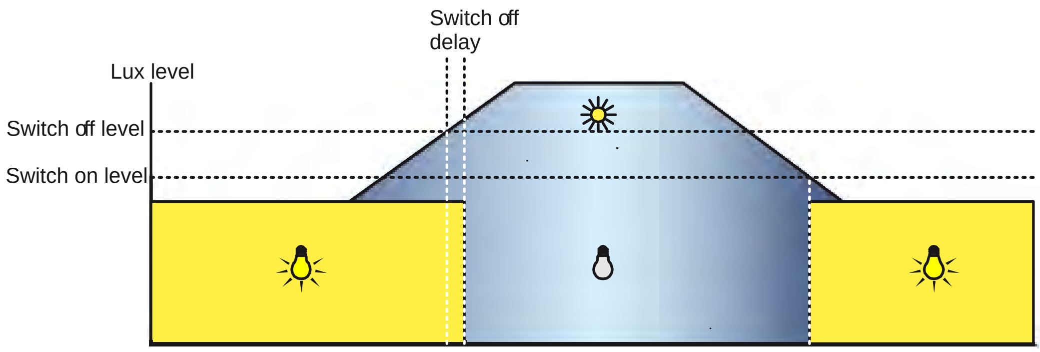


Figure 14 – Daylight switching

4.2.5.4 Daylight regulation

Daylight regulation is a more advanced way of daylight control and can only be used with dimmable lighting. When using daylight regulation the system dims the artificial lighting depending on the amount of daylight, in order to keep the total light level at a predefined value.

Since a window area receives more daylight than a corridor area, the window and corridor luminaires can be controlled with a configurable offset. Depending on the amount of daylight entering the room, both the window and corridor luminaires are dimmed, but with an offset. The window luminaires act as master, and the corridor luminaires will always have more output.

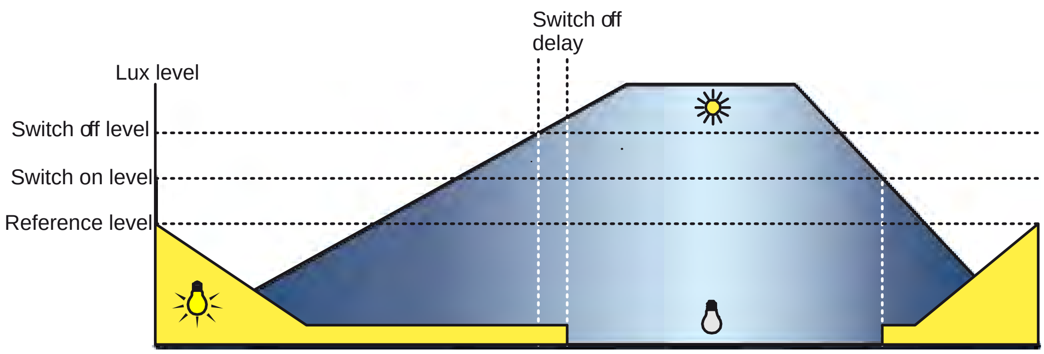


Figure 15 – Daylight regulation

4.2.5.5 Combined daylight regulation and daylight switching

When daylight regulation and daylight switching are combined, the most effective control is gained. When both window and corridor rows have been dimmed to the minimum level for more than a set amount of time (for example 15 minutes), one or both rows will be turned Off to ensure maximum energy saving. The corridor side will by default not switch OFF, hence indicating to the user that the lighting is operational. It is however possible to configure corridor side to be switched OFF completely.

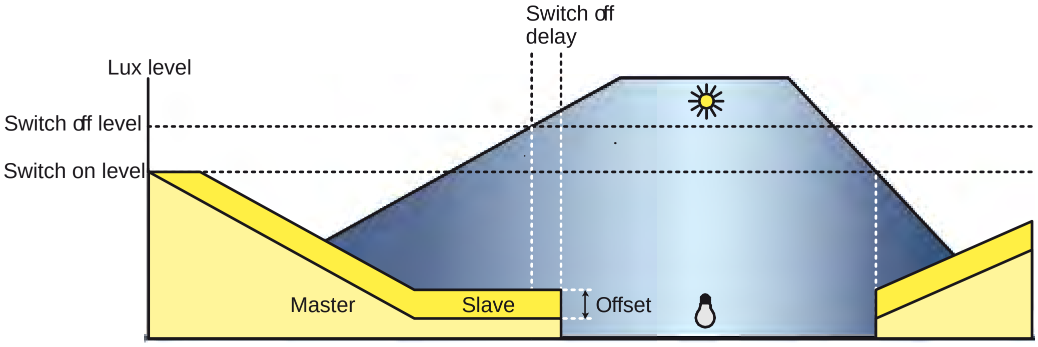


Figure 16 – Combined daylight control, with slave offset, switching all Off

4.2.6 Corridor-row offset

Areas adjacent to windows receive more daylight than those closer to the core of the building including corridors in open space offices. This feature enables the luminaires in the window areas and the core areas to be regulated by a different factor. The window area luminaires are dimmed to a lower level than the luminaires in corridor or core areas. The area in between is dimmed to a pre-defined percentage considering both window and core area levels. This function is identified as corridor row offset.

4.3Personal Control

4.3.1 Manual control

In many situations building occupants may not wish to rely on the automatic daylight harvesting function as the available daylight or low illumination levels present will suffice. Having manual light level control enables the occupant to switch or adjust the lighting level to their personal preference.

Occupants may prefer to override the automatic lighting control if performing different tasks. In particular, intense computer screen work or working on fine detail. Controls may be programmed to resume automatic operation after a time-out period.

4.3.2 Panels/Switches

The obvious way of providing personnel or local control is via the provision of switch panels at the point of entry into areas or zones. Allowing the occupant to decide to turn on the lights or not when they enter the area is a simple energy management practice. If the lights are turned on, then the system will still turn off the lights after they leave following a predetermined time-out period.

4.4Time Control/Scheduling

Many lighting functions are time of day dependent for example, the level of light required for office cleaning or during a security scan walk-through, is considerably lower than that required during normal office hours. Scheduling allows lights to be switched on, off or dimmed, according to a specific schedule. This can be adjusted for weekends, public holidays or other shut down periods.

4.5 Combined Control

While the LightMaster system can be controlled in multiple separate ways, these ways of control can also be combined. When combining, various extra options of control can be used. This section shows the different functions that can be used with combined control functions.

The following table shows an overview of the changes in behavior when using combined control. When more functions are combined (for example a combination of manual, occupancy and daylight control) the system will combine all changes.

Day-light	Occu-pancy	Manual	Sche-duler	Behavior
✓	✓			Lights will only switch On if the area is occupied. If daylight regulation is enabled, the lighting will automatically be regulated according to the required light level. If daylight switching is enabled, the system will keep the lights of an occupied area Off when the level of daylight is sufficient
✓		✓		If daylight switching is used, the system will switch the lights Off when sufficient daylight is available. Depending on the configuration, the lights may stay off if the daylight level drops. Manually selecting a scene changes the required light level. Manual dim commands can be configured in two ways: • Disable daylight regulation, and adjust momentary light level. • Maintain daylight regulation, and change the required light level
✓			✓	Scheduler control can change the required light level (by selecting a scene), and disable/enable/change the daylight control (by selecting a mode).
	✓	✓		Occupancy control can be combined with manual control in three different modes: 1. Presence mode The system uses occupancy control as normal: automatically switch the lights On when the area is occupied, and switch them Off when unoccupied. If the user manually switches the lights Off, the automatic switching is disabled until the area is unoccupied. 2. Absence mode The user must switch the lights On manually. The system will automatically switch the lights Off when the area is unoccupied. 3. Conditional mode The system will use occupancy control as normal, but only if enabled by manual control. If the last manual command was to switch On, the lights will automatically switch On and Off based on occupancy. If the last manual command was to switch Off, the lights will not switch automatically On (until manual On). Other manual control commands (selecting a scene, dimming) work as normal.
	✓		✓	The system will switch the lights On and Off based on the occupancy detection. Scheduler control can change the light level (by selecting a scene). Scheduler control can disable/enable/change the occupancy control (by selecting a mode).
		✓	✓	Lights will be affected by both the manual or scheduler control. The command that is given last will prevail. The scheduler can NOT disable or change the manual control

4.5.1 Combined control examples

This section shows some examples on the use of combined control.

4.5.1.1 Manual and occupancy control in cellular offices

Each of the three offices shown contains an occupancy detector in the ceiling and a wall switch next to the door.

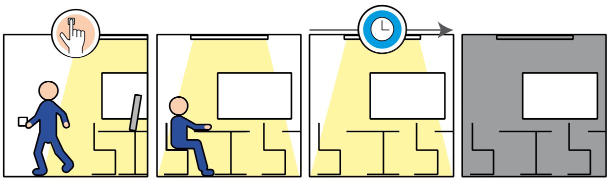


Figure 17 – Cellular office

If the control function in these offices is in an unoccupied scene the luminaires must manually be switched ON. When a room is vacated for more than 15 minutes, the luminaires will automatically switch OFF.

4.5.1.2 All controls in open plan offices

In the open plan office shown, each working area contains a multifunction-sensor (occupancy sensor and daylight sensor) in the ceiling. Each working area has its own manual control.

Each working area uses occupancy control: the luminaires are automatically switched ON when the area becomes occupied and switched OFF when the area is left unoccupied. All working areas are coupled to the corridor area using corridor hold-on, so that the corridor stays lit as long as any of the working areas are used.

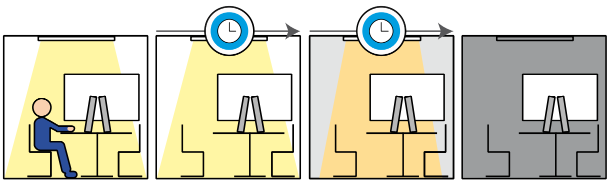


Figure 18 – Open plan office

The light level of each working area is automatically controlled using daylight control.

The manual control is used to manually switch the corridor lights ON, and to adjust the (required) light level in the working areas. The corridor is switched ON manually, and corridor hold-on to stay ON as long as any of the working areas are occupied.

Scheduler control is used to set the lighting in a different mode during the night: the mode of occupancy control in the working areas is then set to an unoccupied scene. It then requires manual operation to switch the lights ON, in order to save energy during cleaning and security rounds.

4.6 Specialized Control

4.6.1 Load Shedding

This function allows some or all luminaires to dim or switch off when the buildings energy consumption is in excess of predefined limits. This maximum limit can be static or dynamically set, possibly by the energy provider. When configured correctly, security, personal safety and comfort are maintained at the highest levels possible. Appropriate low energy consumption presets can be configured and recalled as required. This function is implemented, through dry contact interface or integrated via KNX network using scene based control.

4.6.2 Emergency Linking

Through a dry contact interface it is possible to link various systems, e.g. fire and security, to the lighting system so as to ensure required lighting is switched on during emergencies. Appropriate emergency presets can be configured and recalled as required. This function is implemented, through dry contact interface or integrated via KNX network using scene based control.

4.7 Monitoring

Building management systems or third party software can interrogate the system across the KNX network to determine status and operating information of the system.

4.7.1 Monitor live status on network

Makes real time occupancy information available on a network, either to monitor it or to share it with other building functions, for example HVAC, access control and window shading.

4.7.2 Status Visualization

The system can display information pertaining to luminaire and window shade status on a display such as a touchscreen, PC monitor or a smart phone/tablet

4.7.3 Automated Emergency Luminaire Testing

This feature enables remote activation, monitoring and reporting of emergency lighting system testing.

4.7.4 Run Hours Logging

The system can log the time a specific luminaire is powered. This can assist in reducing maintenance costs and can improve safety and comfort for the occupant, due to the fact that end-of-life for the lamps can be predicted. This also enables planning of systematic group lamp replacement, which is more economical than individual lamp replacement.

4.8BMS & Other Integration

LightMaster can also be used with other building management systems, such as a HVAC system (heating, ventilation, and air-conditioning) and a sunblind control system. Integrating with other building control systems can provide additional energy savings, lower initial set-up costs and increased levels of occupant comfort. An example of this would be a sensor not only determining luminaire behavior but also the behavior of window shades and ventilation systems. Likewise, system switch panels could also control AV equipment or door locks.

4.8.1 HVAC

Occupancy detection or local control devices can link to HVAC systems, (Heating, Ventilation & Air conditioning) to provide control of those devices. Temperature set points can be altered via the system with touchscreens, IR remote controls, etc.

4.8.2 Blinds

Occupancy detection and local control can link with window shade devices such as blinds and shutters. The Philips/Somfy alliance ensures a seamless integration in many applications.

4.8.3 A/V, Security, Lifts

Integrating the control of various devices over the one system is a common requirement. A single pushbutton on a switch panel can be configured to perform multiple tasks simultaneously.
An example would be a shut-down mode scene that can progressively switch off all lighting areas, HVAC systems and enables the security system.

4.8.4 City Landscape View

Many local government agencies that control given city precincts require buildings to meet required night time appearance specifications. Cities generate substantial economic activity via tourism and entertainment; therefore they want their cities to appear alive at all times. If all buildings switched all lights off after hours there is a risk that a city would appear uninviting to tourists & residents. Many cities therefore require buildings to maintain a "lights on" mode after hours. Though the use of scheduling and addressable ballast control technology, the LightMaster system makes it possible to meet this requirement by maintaining a minimum number of lights in the ON state after hours. This normally involves scheduled control of perimeter lights, (located near street facing windows).

5 Solution Design

Designing a LightMaster system for any application takes more than just selecting components. One must interpret the requirements of the customer and translate these requirements into functionality of the system. Also the network structure must be carefully planned.

Before designing the system, the following information must be available:

- Floor plans
- Electrical plans
- Load schedule
- Customer requirements

When all of the above is available, perform the following steps:

1. Select desired LightMaster functions
2. Select the number and position of Sensors, User Interfaces and Actuators
3. Choose the hardware
4. Design a network structure

5.1 Sensor selection and placement

The most commonly used device after a button panel is the multifunction sensor; combining occupancy (motion) detection and light (level) sensing. Commands are configured using parameters for each of these functions.

For example, a command could take the form; when the light level rises 500 lux, take this action or when the light level drops below this level, take another action. The light sensing and occupancy detection functions can be configured to work together to provide conditional logic control. The sensor can be set up to change lighting levels when motion is detected, but only if the current lux level for the controlled area is below a specified value.

The sensor works in much the same way as a button panel in that a virtual button press is initiated by a change in light level, the presence or absence of motion or a combination of both. The sensor will send a message such as classroom area go to preset scene 2 over five seconds.

Note: The detection area of ceiling-mounted sensors depends on the height of the ceiling where they are installed. Optimum height is 2.4 m. If you want to use a sensor in an application with a ceiling height of less than 2.1 meters, the detection area will be significantly smaller. Using sensors in an application with a ceiling height of more than 4 meters requires using long range sensors. If a normal sensor is used in these applications this may cause unreliable detection.

5.1.1 Occupancy Detection

For applications where little movement is made, such as an office application, the number of occupancy detection sensors must be calculated by dividing the total area of the room with the standard detection area of the sensor. For applications where larger movements are made, such as a corridor or a central hall, the maximum detection area can be used.

5.1.1.1 Occupancy Sensor Placement

The detection behavior of occupancy sensors depends on many factors: variations in temperature, position of the sensor, etc. The following sections describe some basic ways on how to place an occupancy sensor

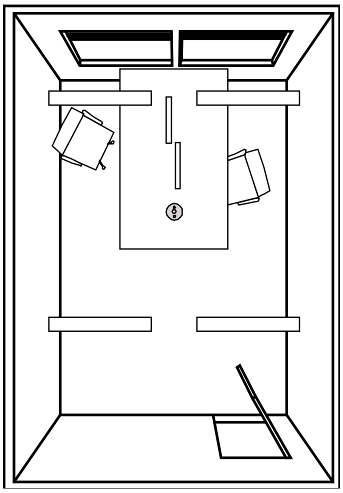


Figure 19 – Position of the sensor

5.1.1.2 Ceiling mounting

A ceiling mounted occupancy sensor must be mounted at a height from 2.1 m to 4 m. Occupancy sensors are designed to detect people performing normal office work in an area of approximately 42 m^2 (5.66 m x 7.42 m) at a height of 2.4 m. This is sufficient for a standard enclosed office (3.6 by 5.4 m). It will however detect larger movements (like people walking) in a larger area.

The following restrictions apply:

- If a person is positioned with their back toward the sensor, most body movement from the arms will be hidden by the person's body. Try to avoid this situation, especially when the person is sitting more than 2 meters away from the sensor.
- Detection directly below the sensor is also less sensitive. The sensor position should be at least 0.5 meter away from the person for an optimal result.

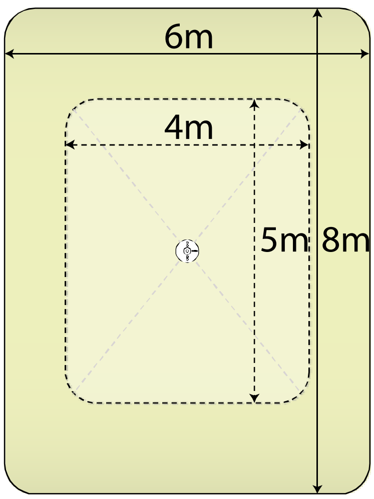


Figure 20 – Example of an occupancy detection range

When a part of the sensor's viewing area should not be used for occupancy detection, the area of occupancy detection can be partially reduced by the retractable view shield. This might be required, for example, in a room with a corridor directly behind a window so that movement in the corridor may affect the occupancy sensor.

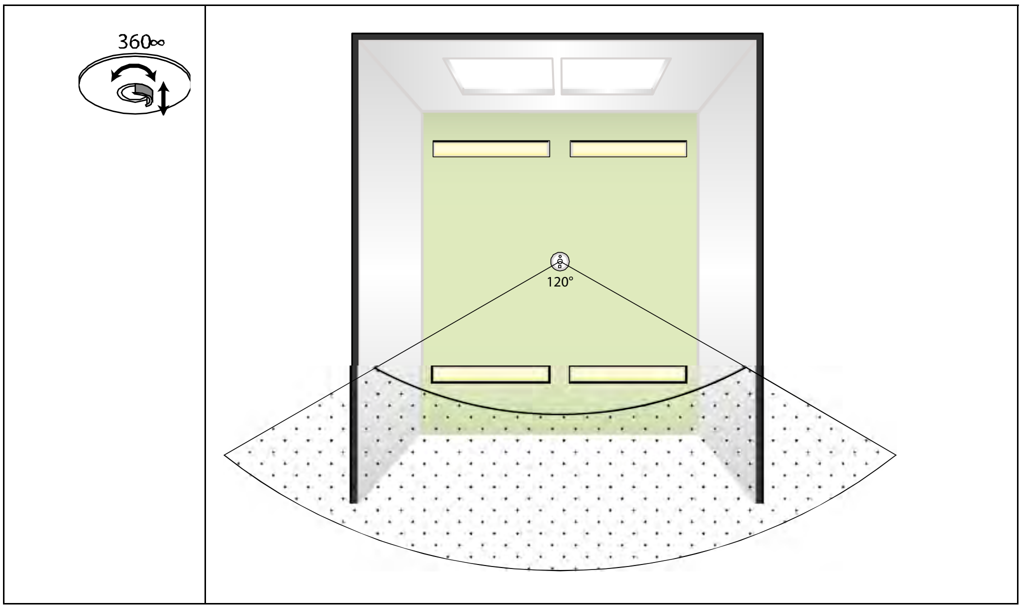


Figure 21 – Shielding the occupancy detection region

Note:

- The Philips types of occupancy sensors are not suitable for security applications.
- If an occupancy sensor is placed in areas where rapid temperature changes can occur, it is possible that the sensor can be triggered unnecessarily and that LightMaster switches the lights ON in unoccupied areas.
- PIR-occupancy sensors detect heat (IR-light) from a person. Glass is usually not a barrier for IR-light. Glass partition walls, walls with large glass windows, or even doors with a window can cause problems. This might be the case, for example, in a room with a corridor directly behind a window so that movement in the corridor may affect the occupancy sensor.

5.1.2 Light Sensing

The daylight sensor should be installed in such a way that it will measure a representative value for the daylight contribution in the area. The detection range of a sensor can be found in the sensor's datasheet.

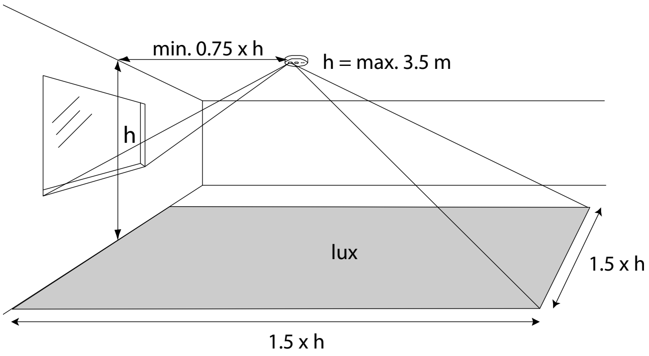


Figure 22 – Light detection range and position

Do not position the sensor too close to the window. If the sensor is mounted too close to the window, sunlight reflections from the windowsill or objects outside (for example snow or a car) can enter directly into the sensor, making the sensor regulate on an incorrect light level.

Note: Do not install the daylight sensor near a window ie. do not have the sensor 'looking outside'. Daylight must not be able to enter the sensor directly.

5.1.2.1 Multiple light sensors in one room

In case more light sensors are present for the same office only one must be used for the daylight harvesting. In these cases always select the sensor that has the best location. To determine the best location, take the following into account:

- The place of the sensor must be representative for all the areas regulated by the sensor. If this is not possible make sure that the darkest workplaces in the area still have the minimum lux level required. This could mean that some workplaces have more light than required.
- If the circumstances in the room differ too much, think about dividing the room into several smaller areas, each with its own light sensor.

5.1.2.2 Light Sensor Placement

Guidelines for placing light sensors include the following:

- Position the light sensor directly above the working area so that it receives only daylight and artificial light from luminaires that are directly controlled by the daylight harvesting control.
- Be careful where furniture is placed in relation to the light sensor.
- The windows should not be visible for the sensor (the sensor should not 'look outside').
- The sensor should be clear of the walls.
- Shiny/white surfaces should be avoided as much as possible.
- Black furniture reflects very little light and therefore hinders proper measurement. Using furniture with a "dark top finish" gives a substantial reflection increase when the desk is covered by white papers. Therefore we do not recommend daylight linking in combination with dark furniture.
- No direct light of any kind should fall onto the sensor (e.g. Up-lighters).
- If there is a master/slave application, the light sensor should only see the light coming from the master lamp. We define a master/slave application as the master and slave having different output levels or are being switched according to different applications.

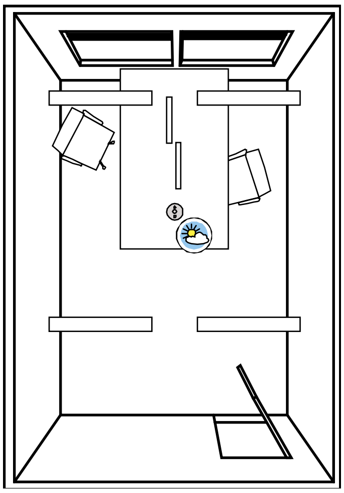


Figure 23 – Light Sensor correctly placed above desk

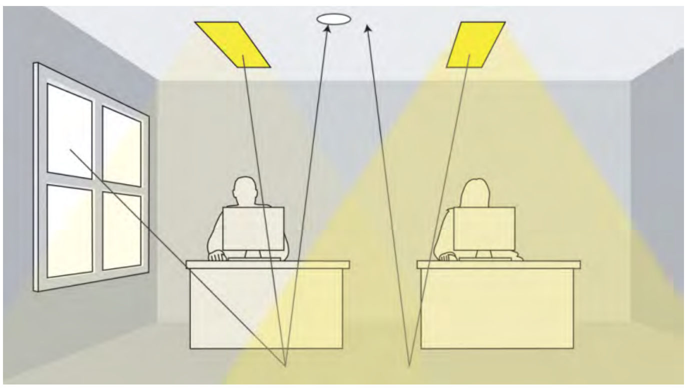


Figure 24 – Only measure daylight and master row

Note: Before using the daylight sensor in an application, it is strongly recommended to calibrate the light sensor.

5.1.2.3 Common Light Sensing Errors

The sensor should not measure light from:

- Luminaires not connected to daylight harvesting
- Luminaires with slave daylight harvesting
- Indirect light, directly shining into the sensor

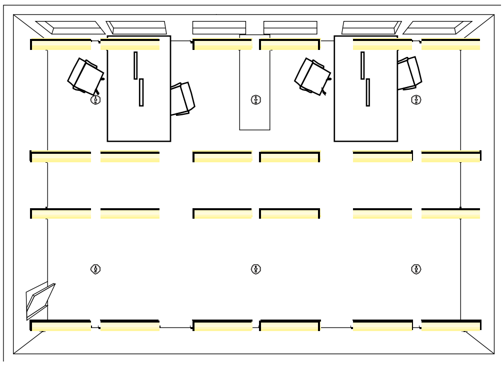


Figure 25 – Common Error 1

Common Error 1 shows the lights sensor positioned above a cabinet istead of near a window. The readings from the sensor will be inaccurate as the top of the cabinet acts as a mirror.

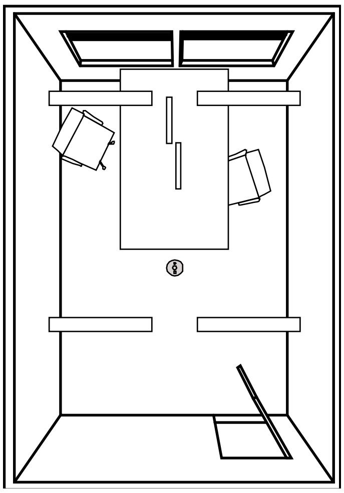


Figure 26 – Common Error 2

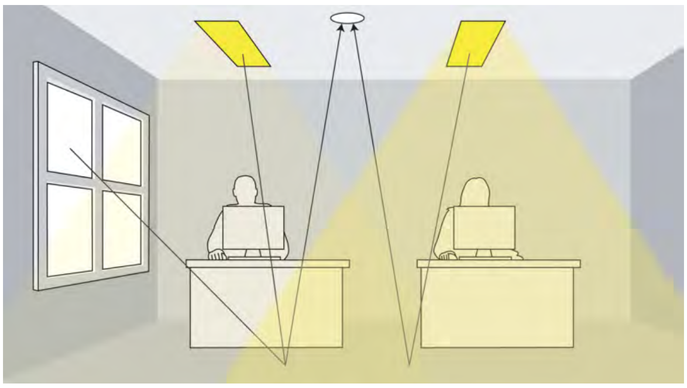


Figure 27 – Common Error 2

Common Error 2 shows that the light sensor measures artificial lights from both rows of luminaires. In a master/slave application, the light sensor should only see the light coming from the master lamp.

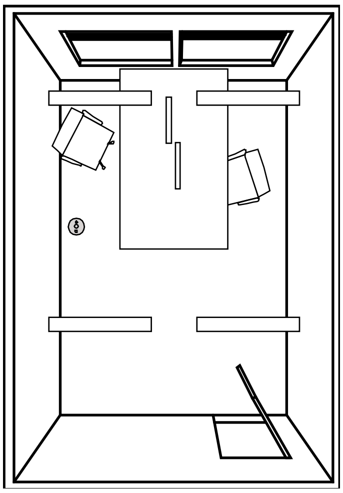


Figure 28 – Common Error 3

Common Error 3 shows a light sensor mounted too close to a wall. The light sensor will read the light level on the wall, instead of the light level on the desk.

Note:

- Do not use Daylight regulation for luminaires in room(s) other than where the sensor is located.
- Daylight harvesting in combination with indirect light sources (luminaires, daylight mirrors) is not possible, or requires special engineering.
- The light sensor has an IP20 approval and cannot be used outdoors, or in a humid environment.
- The light sensor is designed for use at a height of 2.1 to 4 meters in an office environment. Consult a Philips representative for use in other applications, especially at greater heights

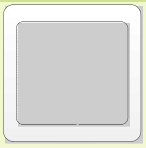
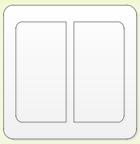
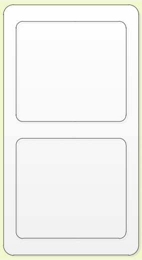
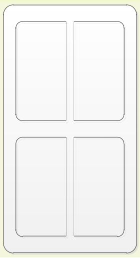
5.2 Button panel selection and placement

Input units are required to control the lights. The most common and simplest are button panels. These work in much the same way as individual light switches, except that each individual button can be programmed to perform a variety of tasks. Using a boardroom example, you would place a button panel at the entrance to access preset scenes such as, Welcome, Conference, Presentation, and OFF. A four button panel is ideal for this type application.

5.2.1 Button panel selection

When determining the type of button panel required, it is first important to ascertain the number of control functions or scenes to be initiated from each location. The button panel must have adequate provision for the total number required. For instance if ON OFF control only is required for a small enclosed office, a single rocker panel would suffice. However for conference rooms where recall of numerous scenes is necessary, it would be appropriate to use a panel that has one button for each scene.

The P1PE-KNX series button panel range is available in a number of configurations as outlined below.

Item Code	Panel Configuration	Number of Rockers	Number of Switches
P1PE-KNX-2P		1	2
P1PE-KNX-4P		2	4
P1PE-KNX-2P-2G		2	4
P1PE-KNX-4P-2G		4	8

The panels incorporate rocker style buttons which pivot from the center to the top and bottom and spring return to the center position. There is a switch located beneath each end of the rocker that is actuated when the rocker is depressed. The parameter for each rocker can be configured to a range of control functions through ETS, as outlined in the table below.

Rocker Function	Function Configuration Options				
Switching (1 objects)	action of rocker:			No action	
				top = OFF, bottom = ON	
				top = ON, bottom = OFF	
Switching (2 objects)	action of upper button:			no action	
				OFF	
				ON	
				TOGGLE	
	action of lower button			no action	
				OFF	
				ON	
				TOGGLE	
dimming	action of rocker for short long / long keystroke:			no action	
				top = OFF / darker, bottom = ON / lighter	
				top = ON / lighter, bottom = OFF / darker	
	Time for long keystroke (200.....1000ms)			500	
blind / shutter	action of rocker for short long / long keystroke:			no action	
				top = DOWN, bottom = UP	
				top = UP, bottom = DOWN	
	Time for long keystroke (200.....1000ms)				
scenes	Scene number upper button (1..8):				
	scene number lower button (1..8):				
	Save scenes with long keystroke		NO		
			YES	Time for long keystroke (200.....1000ms)	
values	datatype upper button	1 Byte	Sub type upper button	Input range 0..255	value upper button (0..255)
				Input range 0..100%	value upper button (0..100)
		2 Byte	Sub type upper button	EIS10 16bit unsigned integer	value upper button (0..65535)
				EIS10 16bit signed integer	value upper button (-32768..32767)
				EIS5 16bit float	value upper button (-671088..670760)
		4 Byte	Sub type upper button	EIS11 32bit unsigned integer	value upper button (0..4294967295)
				EIS11 32bit signed integer	value upper button (-2147483648.. 2147483647)
				EIS9 32bit float (IEEE754)	value upper button (-99999999.. 99999999)
	datatype lower button	1 Byte	sub type lower button	Input range 0..255	value lower button (0..255)
				Input range 0..100%	value lower button (0..100)
		2 Byte	sub type lower button	EIS10 16bit unsigned integer	value lower button (0..65535)
				EIS10 16bit signed integer	value lower button (-32768..32767)
				EIS5 16bit float	value lower button (-671088..670760)
		4 Byte	sub type lower button	EIS 32bit unsigned integer	value lower button (0..4294967295)
				EIS 32bit signed integer	value lower button (-2147483648.. 2147483647)
				EIS 32bit float (IEEE754)	value lower button (-99999999.. 99999999)

5.2.2 Button panel location

Button panels should be conveniently located wherever user input is required to change the state or behavior of lighting control within the user's environment. Typically this would include but be limited to the following:

- Within main entry foyer areas to select overall office modes or foyer scenes
- Adjacent to entry doorways of enclosed offices where user control is required in addition to automatic (sensor) controls.
- In convenient locations along corridors and walkways in and around open plan office areas where user overrides are necessary i.e. for after-hours operation etc.
- Adjacent to entry doorways and presenter podiums within conference and meeting rooms to select mode scenes ie setup, presentation, AV, meeting etc.
- Adjacent to entry doorways in staff amenity areas including toilets, where simple ON OFF user control is provided.

5.3 Actuator selection and placement

There are a number of considerations when selecting the type and number of load controllers. Product details and specifications can be found in LightMaster data sheets, additionally the load schedule can be used to assist you in determining the requirements listed below:

- **Types of loads** – This is of obvious importance, the types of loads need to be known so that the correct types of actuators are selected.
- **Number of loads** – The number (of each type) of loads is required for load actuator selection.
- **Control type for dimmed channels** – choose either a Dimmer actuator or DALI multi-master actuator.
- **Required output per channel** – The required output per channel needs to be determined. This can be calculated by multiplying luminaire rated current by the number of luminaires.
- **Number of dimmed/switched channels** – The number of dimmed and switched channels need to be determined to assist in controller selection.
- **Non lighting applications** – May require the use of a relay actuator for functions like curtain control and fan control.
- **Space restrictions** – The installation area for devices may be quite small and may require the use of DIN rail mounted devices or structured cabling devices in the ceiling cavity.
- **Future expansion considerations** – A common practice is to allow for 20% spare capacity on load controllers and distribution boards. Cabling loops.

5.3.1 Lighting load types

Generally speaking it is possible to deploy ON OFF control to any type of lighting load by using relay actuators. In order to provide lighting level control with the Philips LightMaster KNX range, it is necessary to utilize luminaires fitted with dimmable electronic control gear. In addition to the power supply connections (L, N, & E), these types of luminaires also require a dedicated control signal protocol that is delivered over a separate pair of wires. The following section outlines the protocols that are supported in the LightMaster range.

5.3.2 Light control protocols

5.3.2.1 1-10V

All ballast/transformers on the same physical connection respond together according to the analogue voltage applied. No individual control or reporting is possible.

5.3.2.2 DSI

All ballast/transformers on the same physical connection respond together using an 8 bit dimming value. No individual control or reporting is possible.

5.3.2.3 DALI Broadcast

All ballast/transformers on the same physical connection respond together using a DALI level message to all ballasts in the DALI universe. No individual control or reporting is possible, however DALI broadcast can also be used on DALI addressable networks.

5.3.2.4 DALI Addressable

All ballasts/transformers are individually and group addressable and can provide status reporting. Only one master controller is allowed. User interfaces are connected to the KNX network with commands forwarded to the DALI network by the actuator. The ballasts provide information on request by the control unit only.

5.3.2.5 DALI Multi-Master

All ballasts/transformers are individually and group addressable, can provide status reporting and can respond to messages from the actuator and multi-master devices. This allows several DALI-compliant control units (e.g. sensors or keypads) to all work as masters of the universe. Multi-master control enables easier installation with less wiring.

Note: DALI Actuators will use one or more DALI control methods when addressing devices. Not all control methods are compatible with all devices. The model of actuator will dictate which control methods are available.

5.3.3 Actuator Loading

When designing a control solution, care should be exercised to ensure that lighting circuit loads do not exceed the rated limits of the actuator they are connected to. The output capacity of each actuator is clearly detailed in the published datasheets.

The solution design process for DIN rail mount style actuators is generally quite straight forward, as these devices have output capacity ratings consistent with typical bulk lighting circuit loads. Structured wiring style actuators require somewhat more solution design consideration, as they are intended to be installed as part of a distributed wiring layout right across the application ceiling space. The rated outputs are therefore designed for limited lighting loads of single or several luminaires only.

Item Code	Switched Output Rating Per Channel	Dimmed Output Loading Per Channel
PLPC905GL-(3,4)-KNX	5A resistive / 1A electronic ballast load (inrush current max. 100A per ch).	DALI/DSI, 5 Loads 1-10V, 5 Loads
PLPC905GL-(3,4)-HD-KNX	5A resistive / 2A electronic ballast load (inrush current max. 200A per ch).	DALI/DSI, 7 Loads 1-10V, 10 Loads

The PLPC905GL controller is suitable for connection to a supply rated and protected up to 20A. This enables more than one controller to be connected to a single lighting circuit. Care should still be exercised when considering circuit loading as lighting fixtures which incorporate electronic ballasts tend to draw high power-up inrush currents. Nuisance tripping of circuit breakers can result if loading is not carefully considered. The PLPC905GL incorporates a control feature that staggers operation of the power relays by 100mS to minimize potential inrush currents. For a typical C characteristic thermal magnetic circuit breaker, it is recommended that a de-rating factor of 0.6 be applied when calculating total circuit loading.

For example, a typical 2 x 28W T5 light fixture operating on 230V nominal supply will draw approximately 0.3A. When fed from a 16A protected lighting circuit, this permits a recommended total load of approximately 32 lighting fixtures (16 x 0.6 / 0.3). If using the PLPC905GL with a single fixture connected to each output it would be possible to connect 4 controllers to one 16A lighting circuit as illustrated below.

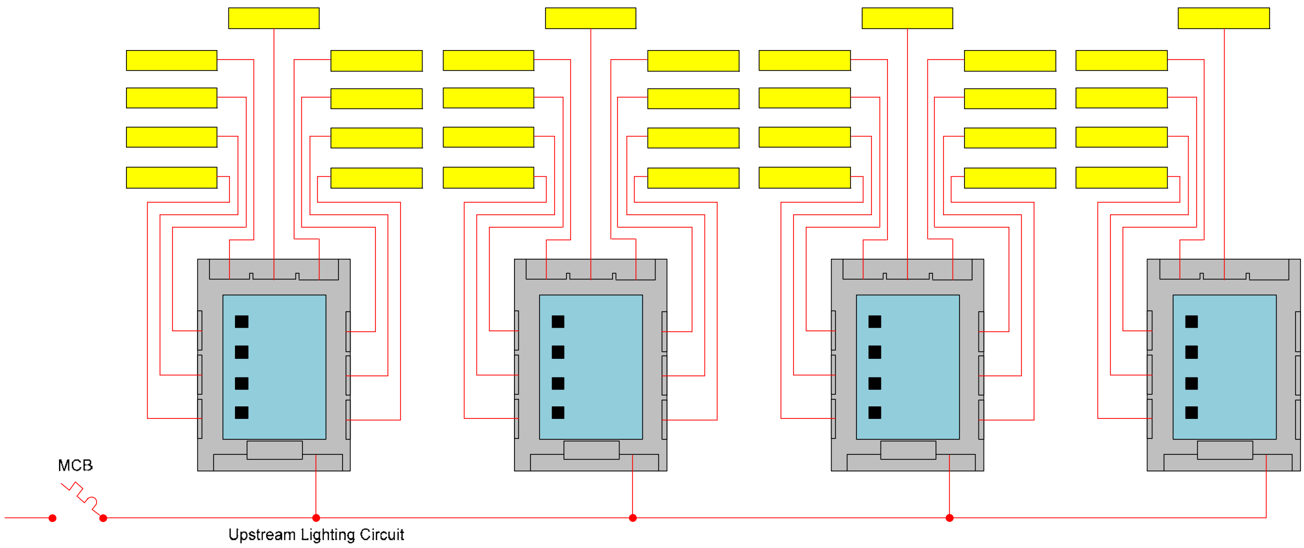


Figure 29 – Actuator loading

The PLPC905GL-HD can also support multiple light fixtures connected to a single output to deliver greater economy if required. The most common application of this approach is where all light fixtures in an executive office are connected on one circuit. Care again should be exercised with this approach to not exceed output capacity limitations. It should be noted that each group of three output channels (CH1, 2, 3, CH4, 5, 6, CH7, 8, 9) is protected by a replaceable internal slow blow 6.3A HRC fuse. As with total circuit loading, a de-rating factor should also be applied to each protected group of outputs if electronic ballasts are used to prevent degradation of the fuses.
For the slow blow HRC fuses utilized in the PLPC905GL a de-rating factor of 0.8 should be used. Using the 2 x 28W T5 example again, this would permit a total of 16 fixtures (6.3 x 0.8 / 0.3) per protected group.

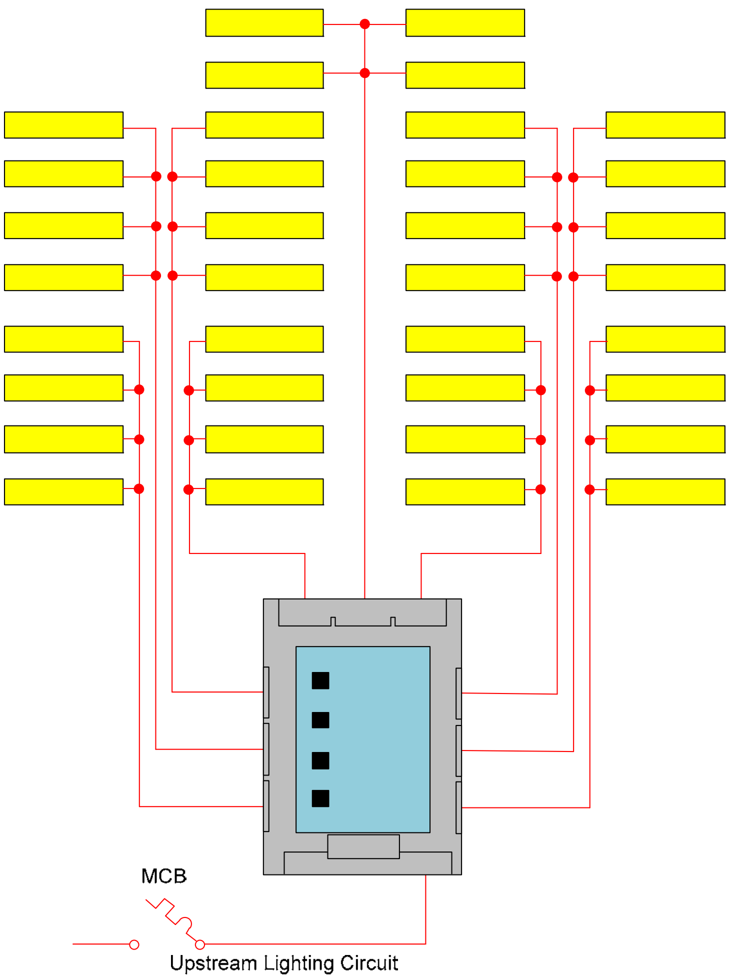


Figure 30 – Upstream/Downstream wiring

Upstream supply lighting circuits are generally wired with 2.5mm^2 cable as applicable for 16A or 20A loading and protection typical for these types of circuits. One major advantage of including output protection within the PLPC905GL, is that it permits a gauge break in the size of conductors used for the output wiring. This may vary between jurisdictions dependent upon codes and practices; however the integral 6.3A fuse protection generally allows 1.0mm^2 wiring to be used on output circuits. This reduction in output conductor size can significantly reduce the cost of wiring an installation.

5.4 Network device selection and placement

The design of the network is very flexible as KNX devices on a line can be connected in daisy chain, tree or star configurations.

To construct the KNX network topology line couplers are used connect lines to other lines or to connect to main lines, and backbone lines. Network Power supplies are used on each line to ensure signal strength is maintained. All actuators are connected to the KNX network however; sensors and user interfaces may be connected to KNX or DALI if using the DALI multi-master actuator.

Note: For applications where corridor luminaires need to be assigned to a parent area, and linked to the presence of users in the adjacent offices, KNX multifunction sensors must be used.

The network design is primarily driven by the following considerations:

1. Number of floors in the building
2. The layout of each floor in the building
3. Network device loading limits
4. Comparative cost of different ballast types (DALI, DSI or 1-10v)
5. Length and cost of light control cable
6. Number and type of loads/circuits to be controlled
7. Hardware requirements list (Number and type of actuators, sensors and user interfaces)

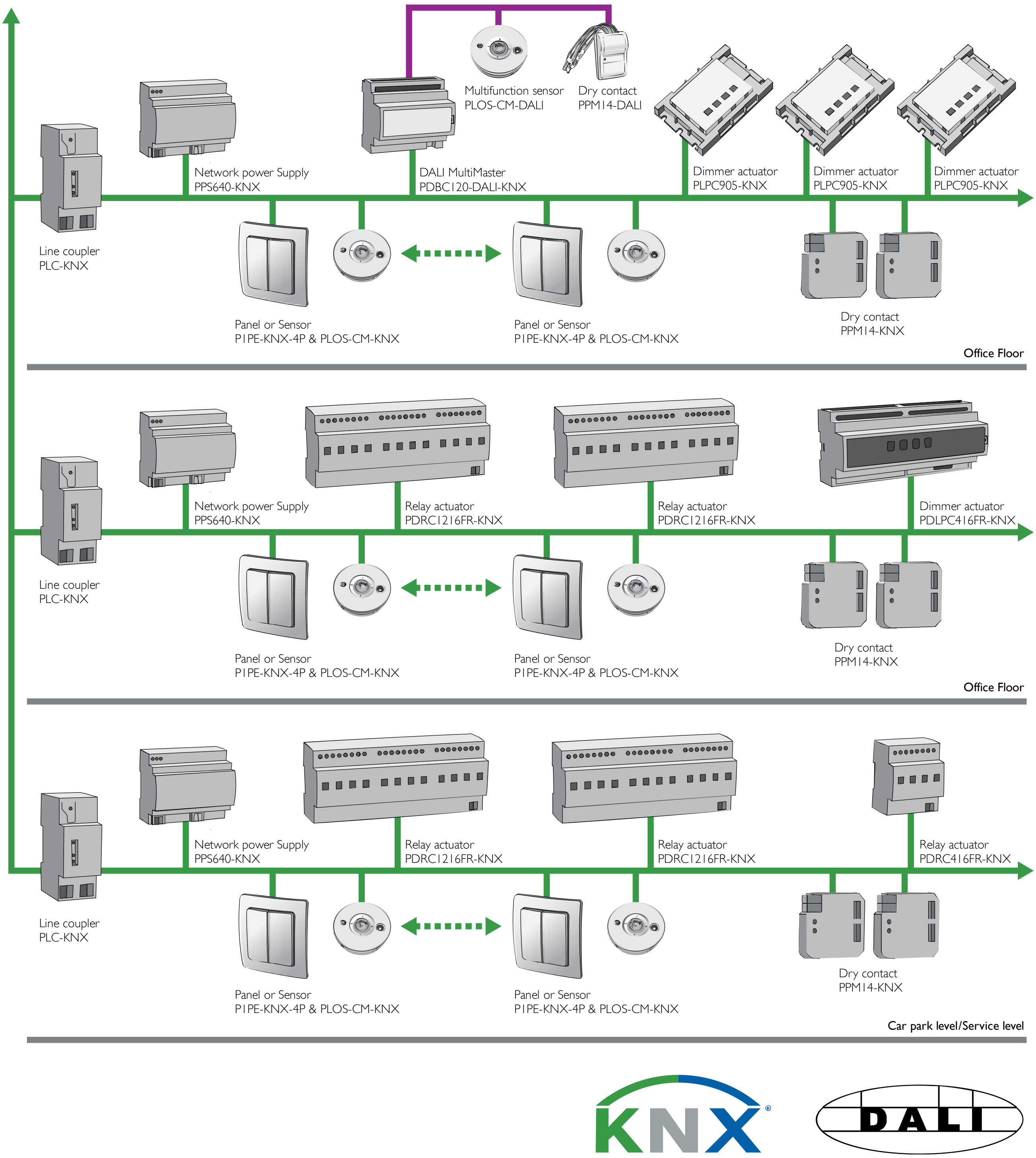


Figure 31 – LightMaster network office building example

5.4.1 Dry contact interfaces

A Dry contact interface works in much the same way as a button panel, in that a virtual button press is initiated by a relay closure in another system such as a security system, alarm system or by any control system with a dry contact output. These inputs can be used to provide status or command information to the LightMaster system.

Inputs can be programmed to create a number of actions in a similar way to button panels.
Dry contact interfaces are available for the KNX bus or the DALI bus to allow flexible interfacing

5.4.2 KNX Coupling Units

There can be a number of reasons to add a coupler to your project:

- Use to create the topology of the KNX network
- Use for galvanically isolating areas in a network
- Use when exceeding current limit of the cable
- Use when exceeding maximum number of devices on a single line segment
- Use when exceeding the 300m maximum distance from power supply limit
- Use when exceeding the 1000m cable length limit

KNX networks are composed of a Backbone Line, Main Line, and Line. KNX topology allows for the following number of network elements:

15	Areas
15	Lines
64	Bus devices per line segment
4	Max segment per line
15424	Bus devices
57375	Bus devices with booster

5.4.3 KNX Power Supplies

A Dedicated KNX bus power supply is required on each line segment of a KNX network, to establish the communications physical layer and provide power to network devices.

5.4.4 Network limitations

5.4.4.1 KNX addressing

KNX devices must have individual addresses in the following ranges.

Physical device	Individual address range
Not Used Address	0.0.0
Backbone Line Root Devices	0.0.z ; z=1~255
Backbone Couplers	x.0.0 ; x=1~15
Line Couplers	x.y.0 ; x=1~15, y=1~15
Main Line Root Devices Address	x.0.z ; x=1~15, z=1~255
Line Device Address	x.y.z ; x=1~15, y=1~15, z=1~255
Main Line Devices & Line Devices	All others

5.4.4.2 DALI addressing

DALI devices require enumeration using the enumerate procedure, where each ballast in a universe is accessed and given a unique address by the actuator.

Standard DALI devices have the following specifications:

- 64 Devices maximum per universe
- 16 Groups per universe
- 16 Scenes per universe
- 24V DC max 250mA Power Supply
- 2 Core (240V rated) data cable
- Manchester encoding method
- Data rate 1200 bps

The transport layer requires only two wires plus a DALI power supply and is not polarity dependent.

Caution: Although the voltage on the DALI wires is low (typical 16V), the system is only provided with basic isolation. Therefore the DALI control wires must be treated as mains wires. Any mains-voltage rated wire or cable can be used).

The length of the DALI wires is limited to 300m; to be able to guarantee reliable DALI communication the voltage drop over the wires must be limited to 2V. Therefore it is advised to adapt the diameter of the wires as a function of the length according the table below

Length of wire	Minimum diameter conductor
Up to 100 meters	0.5 mm^2
100 - 150 meters	0.75 mm^2
150 - 300 meters	1.5 mm^2
More than 300 meters	Not recommended

DALI ballasts/transformers consume power to operate even when their fitting is off, approx. 0.2 to 2 watts per ballast (up to 2% of operation power per luminaire).

DALI ballasts have the capability of fully extinguishing the lamps with mains power still applied to the ballast. This can simplify the mains wiring of some implementations as there is no requirement to switch off the mains when the lights are turned off. However, careful consideration should be given before deciding to leave the mains permanently applied to the ballasts as the control electronics in each ballast continue to draw energy even when the lamps are extinguished. With some brands of ballast this "off state" power consumption can be significantly high to become an energy management and wiring issue, particularly on sites with large numbers of ballasts.

Better designed DALI Actuators have a built in energy saving feature where they automatically switch off power to the ballasts when all ballasts in a universe are off.

5.5 Hardware selection for typical applications

5.5.1 Enclosed Office

The following example illustrates the possible solutions for enclosed offices.

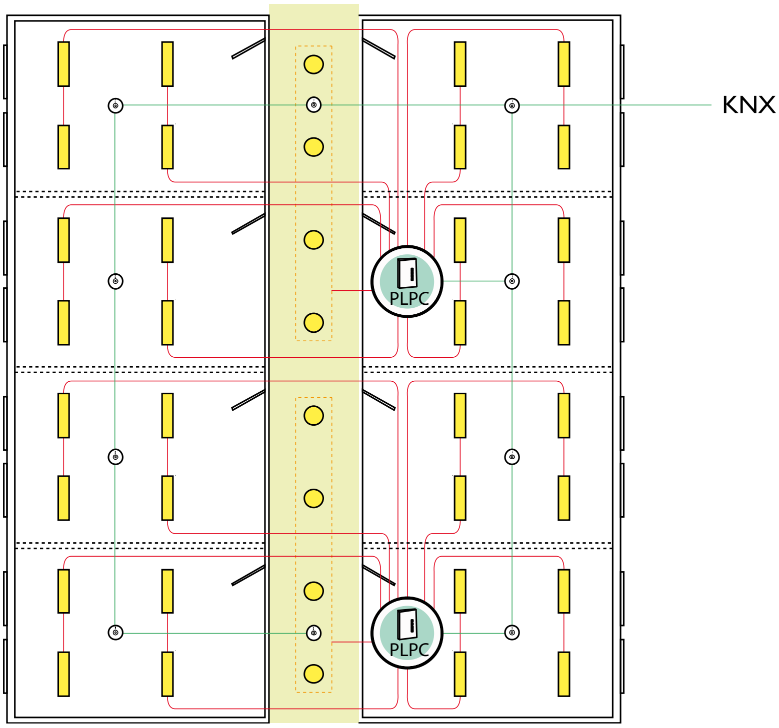


Figure 32 – Example enclosed office layout using Structured Cabling Light Control Actuator and KNX sensors

A typical solution for enclosed office is to use the LightMaster Structured Cabling Light Control Actuator in the ceiling cavity or a LightMaster DIN Rail Actuator in the electrical cabinet. The actuator is used in combination with sensors and switches directly connected to the KNX network. Optional inputs can be provided by the KNX dry contact interface.

For the ballasts, DALI addressable, DALI broadcast, DSI or 1-10 V control can be selected, although the most flexible solution is to use DALI addressable control. Groups of ballasts are connected to the actuator using the light control cable.

An alternative solution is to use the DIN rail mounted DALI multi-master actuator.
Luminaires with DALI ballasts can be combined with sensors and switches directly connected to the DALI multi-master network. The DALI multi-master actuator also operates as a gateway passing messages between the KNX and DALI networks.
Optional inputs can be provided by the DALI multi-master dry contact interface or the KNX dry contact interface.

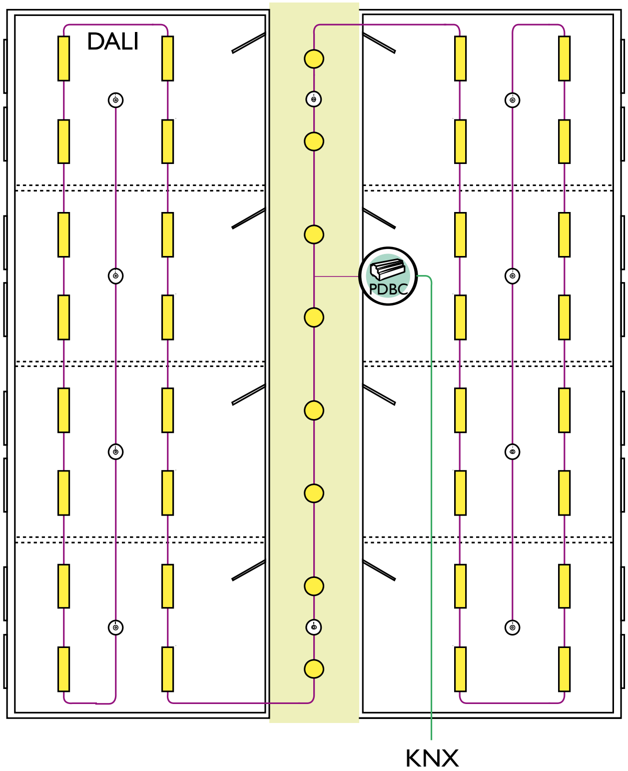


Figure 33 – Example enclosed office layout using layout with DALI multi-master and DALI sensors

All offices can be controlled independently, using a combination of personal control and occupancy detection.

Note: For applications where corridor luminaires need to be assigned to a parent area, and linked to the presence of users in the adjacent offices, KNX multifunction sensors must be used.

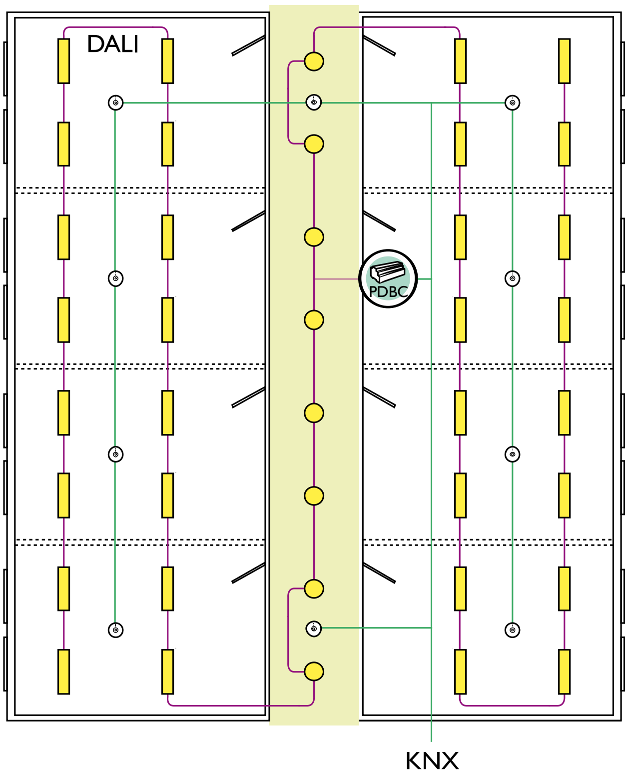


Figure 34 – Example enclosed office layout using layout with DALI multi-master and KNX sensors

5.5.2 Open Plan Office

The following examples illustrate the possible solutions for open plan offices.

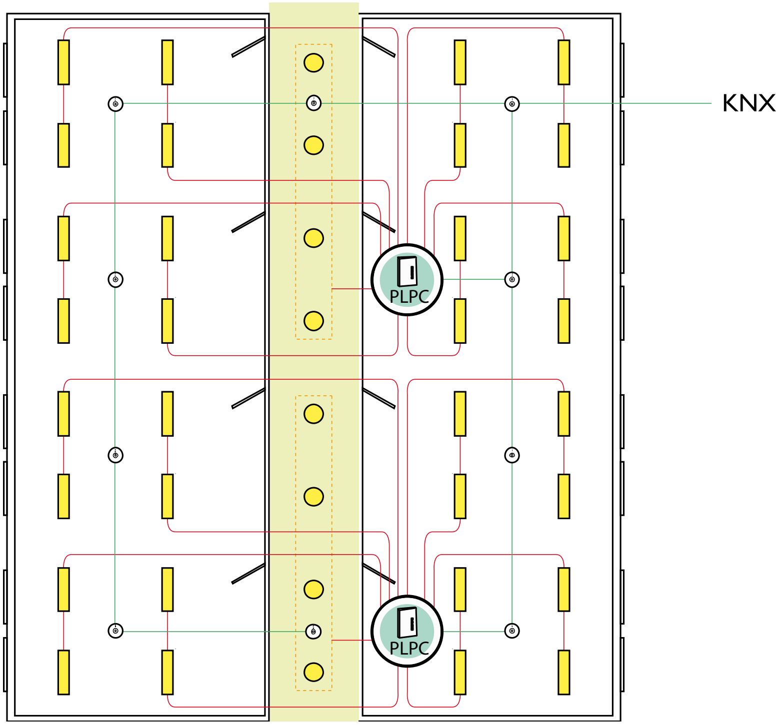


Figure 35 – Example open plan office layout with one sensor per area

A typical solution for an open plan office is to use the LightMaster Structured Cabling Light Control Actuator or the LightMaster DIN Rail Actuator in combination with multi-sensors directly connected to the KNX network. Optional inputs can be provided by the KNX dry contact interface.

For the ballasts, DALI addressable, DALI broadcast, DSI or 1-10 V control can be selected. As indicated, the most flexible solution is to use DALI addressable control. Groups of ballasts are connected to the actuator using the light control cable.

All offices areas can be controlled independently, using a combination of personal control, light level control and occupancy detection Luminaires in the corridor area can be assigned to central control, linked to the presence of users. Occupancy sensors can be used to keep the lighting in the corridors switched ON and the unoccupied part of the open plan on a certain lighting level until the entire area is vacated.

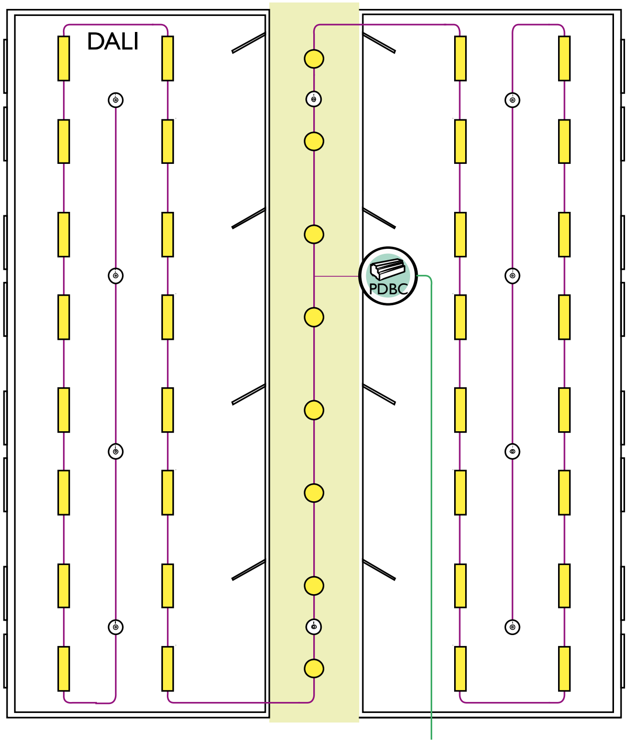


Figure 36 – Example open plan office layout with DALI multi-master and DALI sensors

Luminaires with DALI ballasts can be combined with the DALI multi-master actuator. This solution is based on the usage of switches and sensors connected to the DALI multi-master network. Optional switches and extra occupancy sensors are connected directly to the DALI or to KNX.

Occupancy sensors can be used to keep the lighting in the corridors switched ON and the unoccupied part of the open plan on a certain lighting level until the entire area is vacated.

The layout drawing above shows the basics of the DALI multi-master solution: luminaires are separately connected to mains and the ballasts, sensors and switches are connected to the DALI multi-master network. The DALI multi-master actuator is the only device that must be connected to KNX and also operates as a gateway passing messages between the KNX and DALI networks

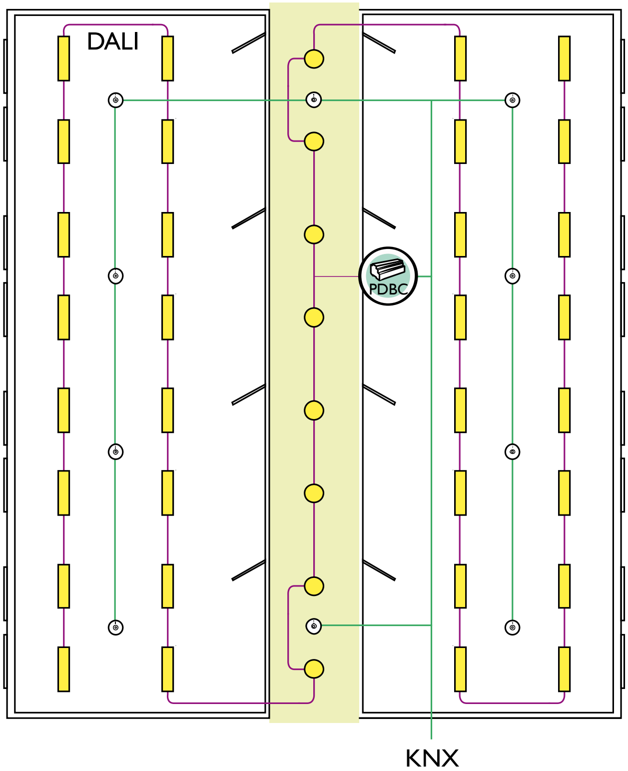


Figure 37 – Example open plan office layout with DALI multi-master and KNX sensors

5.5.3 Core Areas

The following examples illustrate the possible solutions for office core areas.

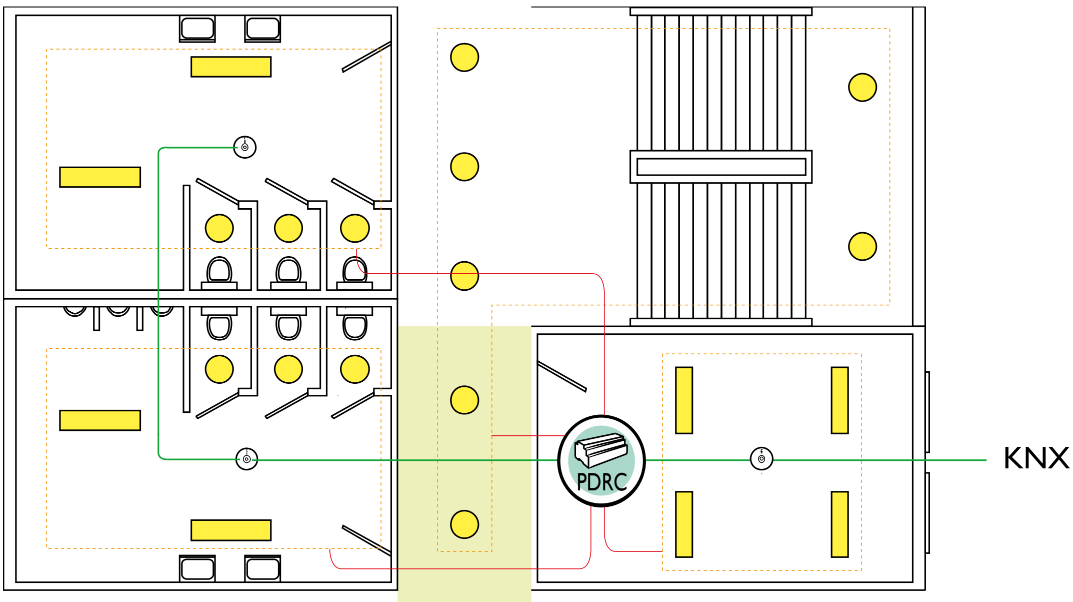


Figure 38 – Example layout of core areas

In many buildings the core area lighting circuits are supplied from a separate 'landlord's' distribution board. It is therefore convenient to locate a DIN rail lighting control actuator at this point.

In the example above, the lights of four distinct areas are connected separately to the outputs of the light controller actuator. These are the main lift lobby, the stair lobbies and the two toilets.

Luminaires with DALI ballasts can be combined with sensors and switches directly connected to the KNX or DALI multi-master network. Optional inputs can be provided by the DALI multi-master dry contact interface or the KNX dry contact interface.

The lighting in the toilet areas is automatically switched ON when someone enters and turned OFF when no movement is detected after the set time-out, typically set to10 or 15 minutes in the ETS Actuator properties. When the size of the area requires a larger detection area, several sensors can notify each other that movement is detected. The lighting in the lobby area is automatically timed out or activated via the network and maintained during all occupied hours.

5.5.4 Meeting Rooms

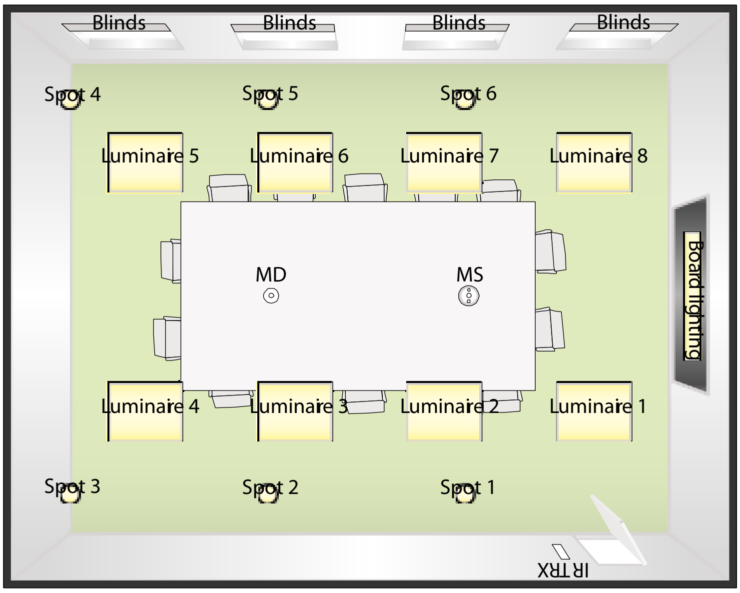


Figure 39 – Example of a meeting room application

The majority of meeting rooms use scene setting to define their lighting level with the further ability to raise and lower lighting from these scenes. The example above shows a typical meeting room that is big enough to require two occupancy sensors and five light control channels for full coverage. The example meeting room also includes HVAC and blind control via a KNX gateway.

Some applications require each of the luminaires to be individually addressed to give the maximum scene flexibility, but the majority will have four well-defined scenes for the room. In the example, the corner spots 1, 3, 4 and 6 are on channel 1, and spots 2 and 5 on channel 2. The board lighting has channel 3 as it will be switched ON and OFF separately. The fluorescent lights 1, 2, 7 and 8 have channel 4, whereas lights 3, 4, 5 and 6 take the final channel 5. This allows for a special scene for projector use where the lights graduate from OFF at the front to a higher level at the back of the room. It also allows for half the room to be used for smaller meetings.

Possible functions in this example are:

- Upon entering the room, the default scene is started. This could be, for example, to have all fluorescent lights come ON at 40% to give a general background level or to arrange for only 1, 2, 7 and 8 to switch ON giving the front of the room operation for smaller meetings.
- The occupied status of the room can be passed to the HVAC in order to automatically set the room to a comfort mode.
- With wall mounted buttons the users can choose any lighting scene or change the temperature of the room.
- If the projector is used, a specific scene is set up which fades the lights at the front and switches OFF the board light, and even closes the blinds.
- Leaving the room for longer than the timeout period of the occupancy sensors will switch the lighting OFF and the HVAC to unoccupied mode. Re-entering the room re-starts the default scene.

6 Office Application Example

Designing a LightMaster solution for an office application involves a number of steps and decisions to be taken to ensure requirements are met. This chapter describes the design process for the first floor of an office building.

6.1 Design Approach

The lighting system needs to be designed in accordance with the customer's requirements. Execute the following steps complete the design process:

1. **Select desired LightMaster functions**
   For each of the functional areas, we must specify the LightMaster lighting functions that are needed in that area. For each area, we have to consider: occupancy control, light level control, time control and personal control. Detail how each function will operate in the selected areas.

2. **Select the number and position of sensors and controls**
   To realize the selected lighting control functions, we use a combination of sensors and manual controls (user interfaces). To choose which sensors and interfaces to use, we base our choice on the number and type of functions that will be used in that specific area.

3. **Choose the hardware modules**
   To select the light controller actuators, we first need to know the type and number of circuits and loads that are needed and the power consumption on the control network. When this known, the required hardware can be selected.

4. **Design a network structure**
   To make the system complete, the sensors/user interfaces, networking devices and light controller actuators must be connected to each other. As the system uses a free topology network, the devices can be connected to each other in any order. Sensors and user interfaces come in two types either KNX or DALI and can only be connected to the equivalent control network.

5. **Commission the system**
   To commence commissioning we must first identify the required parameter settings. Therefore we need the customer requirements specifications, to define what input actions and output functions we will use for each area.

6.2 Typical Office Layout

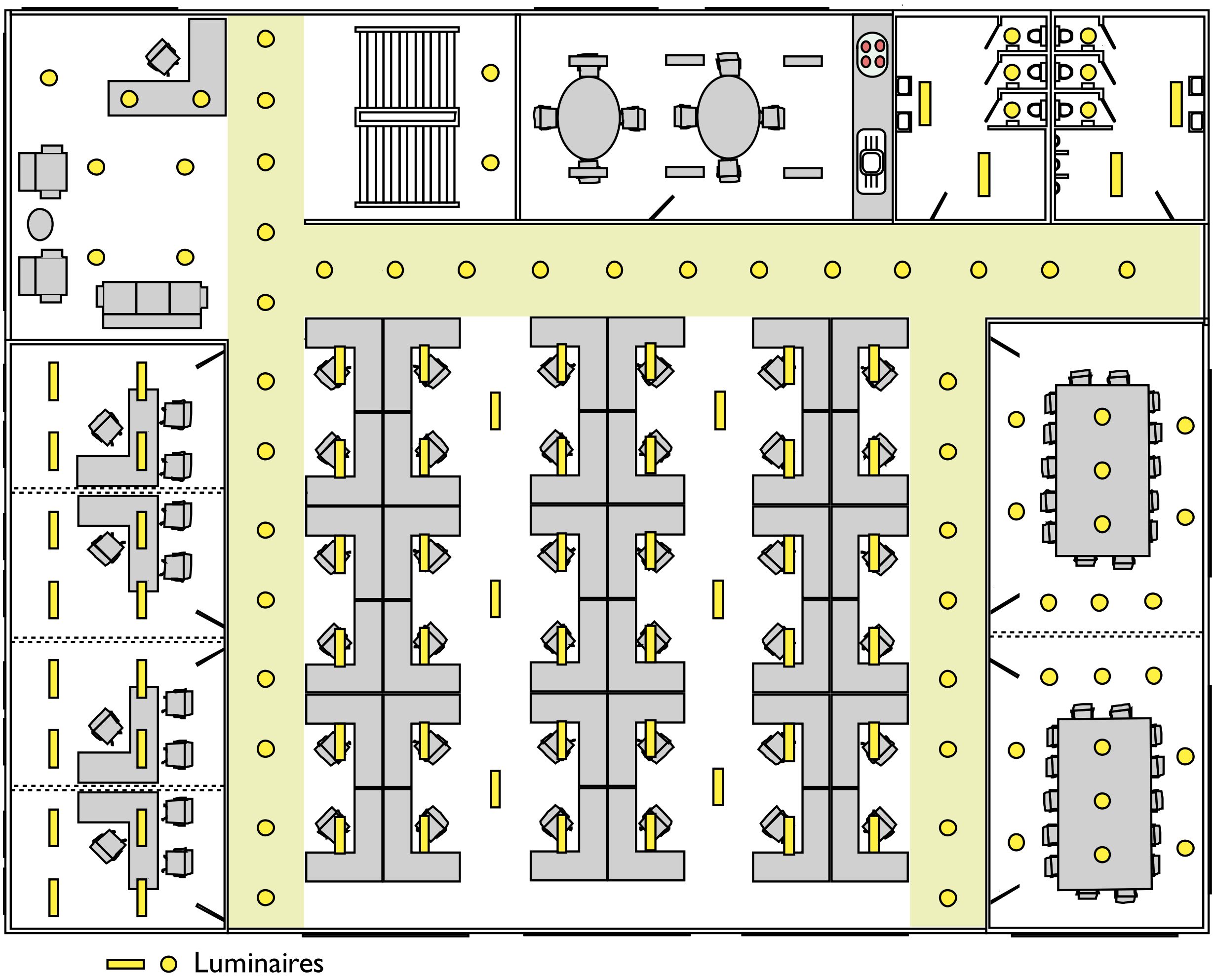


Figure 40 – Typical office layout

A typical office suite could be a single office or just one floor of many tenanted by a large organization. Entry areas are accessible to visitors and clients, hence track or downlights would be found here, in addition to dynamic LED signage that highlights the company logo.

The open plan area would have fluorescent or LED luminaires that are laid out in a regular pattern to achieve uniformity. They are often wired in large blocks and inefficiently switched the same way (this is inevitable where the design is based on an empty floor-plan). For undimmed installations, the cabling may be run parallel to windows, enabling a row of edge luminaires to be daylight switched by the control system.

Meeting rooms show three circuits of downlights, while the fringe areas including staff amenities have just a few essential lights that could be of almost any type.

The evolution of addressable ballasts or luminaire controllers has made it possible to treat individual luminaires as a dynamic component of the space, with lighting over workstations controlled individually or in small numbers. This is becoming more cost-effective considering the frequent rearrangement that takes place in many organizations. The layout appears conventional, but the unique response from individual lamps is achieved electronically, so can be easily modified. In corridors and entry foyers, identical lighting can offer entirely different functions to those above the desks of employees. The behavior of lighting in staff amenities areas may have a different purpose again, due to the low occupancy of the space.

6.3 Functional Outline

The customer wants to maximize the energy savings in lighting, while maintaining ease of use. Accordingly, they have specified the following rules to be applied to the lighting:

- The toilet lighting should be switched manually.
- During the day (8.00 – 20.00) the corridors, stairs and offices must be lit as follows:
  - The luminaires in the offices should automatically turn ON when someone enters the office. The luminaires may dim when daylight is available. When the level of daylight is sufficient to light the whole room, the lights may be switched OFF, but the user must somehow be able to see that the lighting is still operational (and not defective).
  - All corridor lights should automatically turn ON when the first user enters the floor. The lights must not turn OFF during all the rest of the day.
  - The stairways must be fully lit.
- During the evening (20.00 – 0.00) the corridors, stairs and offices must be lit as follows:
  - The luminaires in the offices should be turned ON manually. When nobody is present in the office the lights should automatically switch OFF. When daylight is available, the luminaires may dim.
  - The corridors must be fully lit as long as any person is present in any of the offices or in the corridor itself. When all offices and corridors are vacated, the lights in the corridor may be switched OFF.
  - The stairways must be fully lit.
- During the night (0.00 – 8.00) the corridors, stairs and offices must be lit as follows:
  - The luminaires in the offices should be turned ON manually. When nobody is present in the office the lights should automatically switch OFF. When daylight is available, the luminaires may dim.
  - When nobody is present, the lights must be OFF. Half of the corridor lights must switch ON if someone enters the corridor. When someone is present in any office, all of the lights should be ON.
  - The stairs must be fully lit.

During weekends and holidays the corridors, stairs and offices must be lit according to the night regime.

6.3.1 Entry Lobby

The first person to arrive would be detected by an appropriately located motion sensor or would be required to initiate a system response by pressing the 'ARRIVAL' button on an adjacent button panel. ELV downlights are included to provide an attractive feature at the reception counter. Increasingly, specifiers are using digitally-controlled transformers that can be matched to standard Philips lighting control actuators.

6.3.2 Enclosed Offices

Small offices don't consume a great deal of energy but collectively the total energy of many small offices is significant. In a refurbishment that includes individual offices, it is not cost-effective to hard-wire a conventional switch for just two or three luminaires. Increasingly though, it is becoming mandatory for an occupancy sensing device to be made available.

Executive offices are often as elaborate as a fully-featured conference room. It is often necessary to provide full architectural control, depending on the complexity of the lighting scenes required.

In all enclosed offices different lighting regimes must be used during the day and are dependent on the day of the week. It is therefore a requirement to use scheduler control. Using the scheduler control, we can define other functions in different modes based on time-of-day.

The following requirements are based on time-of-day and occupancy: the lights should react if the office is occupied (someone is present) or not:

- During the day, "the luminaires in the offices should automatically turn ON when someone enters the office." During the evening and night, "when nobody is present in the office the lights should automatically switch OFF". Therefore, the lighting system should use occupancy control for the enclosed offices.
- During the evening and night the lights must be manually switched ON, so manual control is also needed.

Daylight control must also be used in the offices, according to the following statements:

- During all regimes "the luminaires may dim when daylight is available."
- For the day regime the following is added: "When the level of daylight is sufficient to light the whole room, the lights may be switched OFF, but the user must somehow be able to see that the lighting is still operational (and not defective)."

With the four control functions mentioned above, all requirements for the enclosed offices can be covered. We will select the detailed parameters of these functions during commissioning.

6.3.3 Open Plan Offices

Fluorescent lights are generally the most numerous throughout an open plan office area. The choice of internal components is fundamental to the selection of the Philips KNX LightMaster system devices to control them.

Depending on the budget, a degree of sophistication is now available. Dimmable open office lighting is becoming more common for both ergonomic and energy-conscious applications. The ability to dim has a direct bearing on the aesthetics and comfort of the space and is also significant in conserving energy. Luminaires that can be individually addressed and operated, offer a wide range of control possibilities. It can also eliminate the expensive practice of physically modifying the electrical wiring each time the office fit-out changes. A variety of approaches are available, subject to the luminaire control gear and to local energy regulations.

The requirements for enclosed offices would also be applied for open plan areas. However the open plan would not be treated as a single control area, but rather broken into workgroup sections, so that further energy savings can be gained if sections are not occupied.

6.3.4 Conference Rooms

Scene based control is required to adjust the lighting of the space to align with the functions of the room, i.e. presentation, meeting, preparation etc. Occupancy control should also be utilized to ensure the room is shut down when vacant to conserve energy.

6.3.5 Corridors

From the list of requirements, the following list or requirements for the corridors can be extracted:

- During the day the corridors must be fully lit from the moment someone enters.
- During the evening the corridors "must be fully lit as long as some person is present in any of the offices or in the corridor itself. When all offices and corridors are vacated, the lights in the corridor may be switched OFF."
- During the night the corridor lights must be Off except if anyone is present or in any office. Only when someone is in the corridor, half of the lights should be ON. If any office is occupied, all lights must be ON.

Like with the enclosed offices, the corridor lighting is dependent on the time of the day, so the scheduler control function is needed.

During the evening and the night, the lighting of the corridor is dependent on the adjacent enclosed offices. The lighting function to be used here is zone linking. For the evening and night, the corridor is also dependent on its own occupancy state. Therefore the corridor will also use direct occupancy control.

6.3.6 Stairways

When extracting the requirements about the stairways, it turns out that the stairs must be fully lit under all circumstances. This area therefore does not require any lighting control functions.

We choose however to connect these lights to the lighting control system anyway, since the requirements may change at some time in the future. For example, the staircase could be switched OFF from a central point in the building when the last person leaves the building. In that case, the lights can be switched without a need for rewiring the luminaires.

6.3.7 Toilets

The toilets use a simple lighting function: The toilet lighting should be manually switched. This only requires manual control. No daylight control, scheduler control or occupancy control is needed.

6.3.8 Staff Amenities

In these areas, occupancy sensing is usually appropriate with long delay times.

6.3.9 Summary

The following table summarizes what functions will be used where:

Function	Entry Lobby	Enclosed Offices	Open Plan Offices	Corridors	Stairs	Staff Amenities	Toilets
Scheduler		✓	✓	✓		✓	
Occupancy	✓	✓	✓	✓		✓	
Daylight		✓	✓				
Manual	✓	✓	✓				✓
Zone linking	✓	✓	✓	✓		✓	

6.4 Equipment Selection

To realize the selected lighting control functions, we must use sensors and manual controls. To choose which sensors and controls to use, we base our choice for each area on the functions that will be used in that specific area.

The scheduler control does not use a separate sensor or control, but must be included in the system by adding a timer, which can be sourced from a number of reputable third party vendors.

6.4.1 Daylight Harvesting

This is a topic for separate detailed analysis, as each application is unique. During daylight hours, the ingress of natural light can be selectively harvested within parts of the space that have a component of natural light.

Some designers always switch off perimeter lighting, while an increasing number apply light sensors for detecting the natural sunlight available and then dim the lighting accordingly. This action must be carefully undertaken to avoid issues of disturbing or reducing the comfort of those occupying the space. In particular, care should be exercised where window blinds are in use due to the possibility of fragmenting a light detection zone. As with other issues of 'granularity', the solution might be to deploy a greater number of sensors. The challenge of harnessing daylight is to attenuate the artificial light without creating discomfort that is associated with bright windows and dull interiors.

Philips LightMaster KNX networked sensors detect luminance as well as occupancy. They each contain embedded intelligence, enabling their response to be varied at different times of the day. When excess natural light falls on a perimeter row, the occupancy sensor might allow dimming to a very low level in the absence of motion, but dim to 50% when occupancy is detected. This is often necessary to avoid shadowing and provide adequate horizontal luminance on desk surfaces.

DALI ballasts provide an appropriate vehicle for daylight response, as there is no longer a physical connection between the hard-wired circuitry and the ability of individual luminaires to be dimmed. Luminaires that run parallel to the windows may be switched or dimmed, irrespective of their physical wiring.

6.4.2 Maintained Illuminance

This strategy can offer greater savings than daylight harvesting, as previously discussed. In the absence of any natural light (late at night for example), the Illuminance levels of many workstations and corridors are far greater than is recommended in lighting standards. This can be harvested by the step-less dimming of controllable fluorescent lighting. Once a target level has been established, a desirable light level will be maintained irrespective of environmental changes in the space. Savings of 10-20% are typical, while greater than 50% is not uncommon in the retrofit of pre-21st century buildings.

6.4.3 Entry Lobby

To detect the first arrival a PLOS-CM-KNX/DALI sensor is located adjacent to the entry stairway. This would be complimented by a PIPE-KNX-4P to enable specific scenes to be recalled that may relate to the immediate area or other areas of the office.

6.4.4 Enclosed Offices

As it is necessary to provide both occupancy control and daylight harvesting in each enclosed office we can use the PLOS-CM-KNX sensor as it provides both functions. When this multi-sensor is mounted on the ceiling in the middle of an enclosed office, the detection pattern of both daylight sensor and occupancy sensor covers the whole room.

To enable the necessary manual operation, button panels would be installed adjacent to the entry doorways. The requirements for basic enclosed offices only specifies that the manual control should do switching, so the PIPE-KNX-2P two-button panel is sufficient. For the executive office where additional scenes may be required a PIPE-KNX-4P four-button panel would be more appropriate.

6.4.5 Open Plan Offices

Networked KNX sensors may be used to provide saturation coverage of open plan areas.

Multifunction sensors measure the value of luminance in their field of view. This can be harnessed to provide step-less dimming control; both to maintain a pre-determined light level and to capitalize on the availability of natural light. Philips KNX LightMaster sensors support multiple functions allowing presence detection and natural light level measurement from the one device.

6.4.6 Conference Rooms

Wall mounted button panels enable scenes to be selected to the operating state of the room ie presentation, meeting etc. Third party KNX network interfaces can be incorporated to enable inter-operability with audio-visual devices, while many AV systems also natively support the KNX protocol. Multifunction Philips KNX LightMaster sensors are used to detect when rooms have been vacant for a period of time.

6.4.7 Corridors

For the corridors, we need scheduler control, zone linking and occupancy control. Only occupancy control requires a sensor to be added.

To ensure reliable operation, the complete corridor area must be monitored. Therefore multiple sensors should be located at suitable intervals so that their sensing range overlaps.

6.4.8 Stairs

No lighting functions are selected for the stairs, so no components are required. However regulations vary considerably from one jurisdiction to the next regarding how lighting should be controlled in stairways. Local regulations of course must be strictly followed.

6.4.9 Toilets

User button panels shall be located adjacent to the entry door of each toilet, so the lighting can be controlled manually.

6.4.10 Staff Amenities

The luminaires might be the conventional office type or any combination of aesthetic creations. An alternative approach is to have the lights 'ON' during normal hours and to enable a KNX LightMaster sensor or single 'one shot' Philips KNX LightMaster pushbutton panel after hours. In this event, the lights can be flashed off momentarily as a warning, before the lighting is switched off.

6.4.11 Sensor & Button Panel Placement

The illustration below outlines typical sensor and button panel placement to fulfill the application requirements.

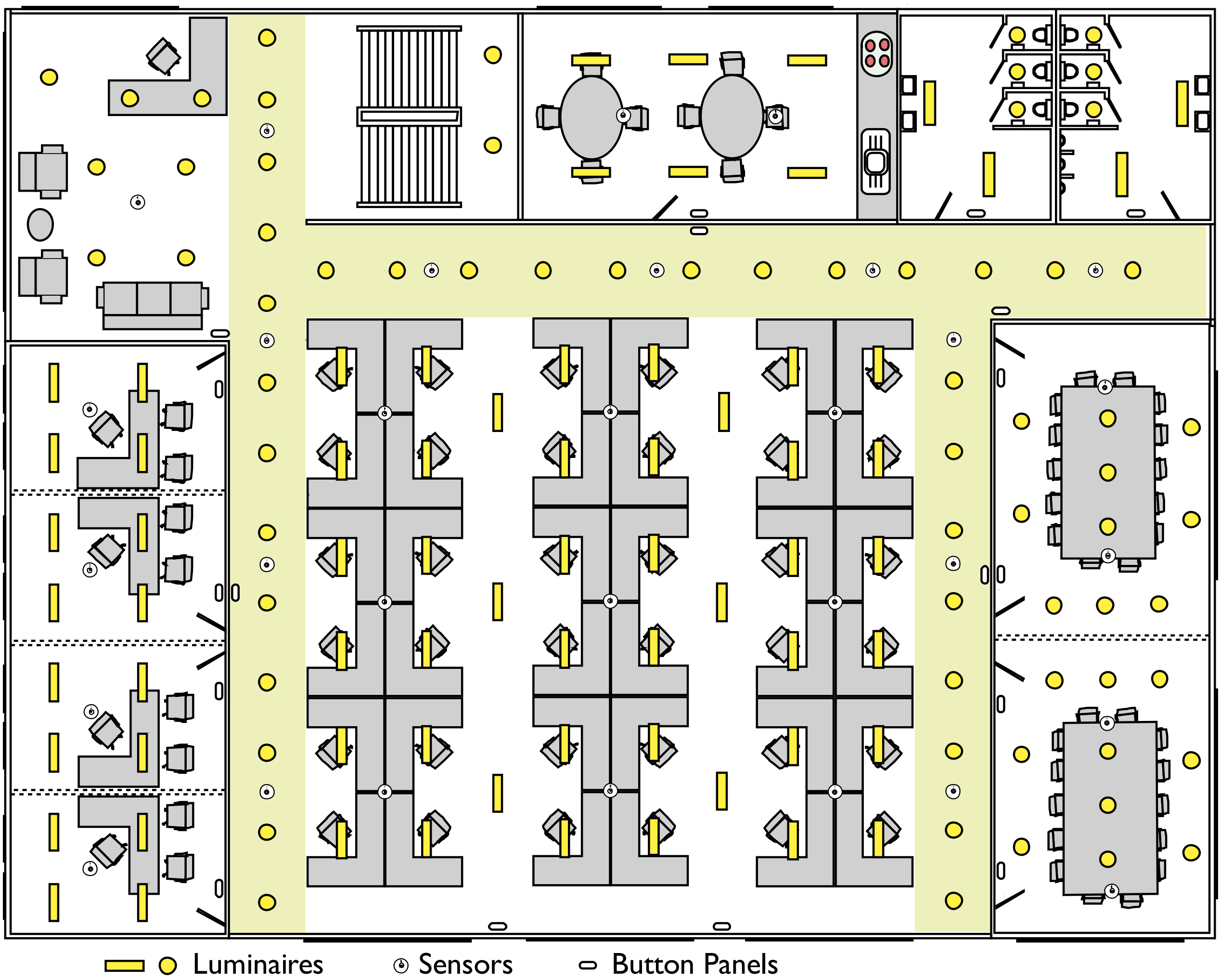


Figure 41 – sensor and button panel locations

6.4.12 Actuators

The type and quantity of actuators is based on the:

- functional requirements of each lighting circuit
- overall number of lighting circuits
- type of lighting circuits

Dimming actuators will be necessary for all lighting in enclosed offices, open plan office areas, corridors, conference rooms and the foyer, as light regulation or scene control is required in these areas. Switching actuators can be utilized in the staff amenity area, toilets and stairways as light level control is not required in these areas.

For this application example the PLPC905GL-3-KNX structured wiring dimming actuators will be used for all regulated lighting circuits.   The PDRC816FR-KNX relay actuator will be used for all switched circuits.

The following diagram outlines how the actuators would typically be wired to the luminaires.

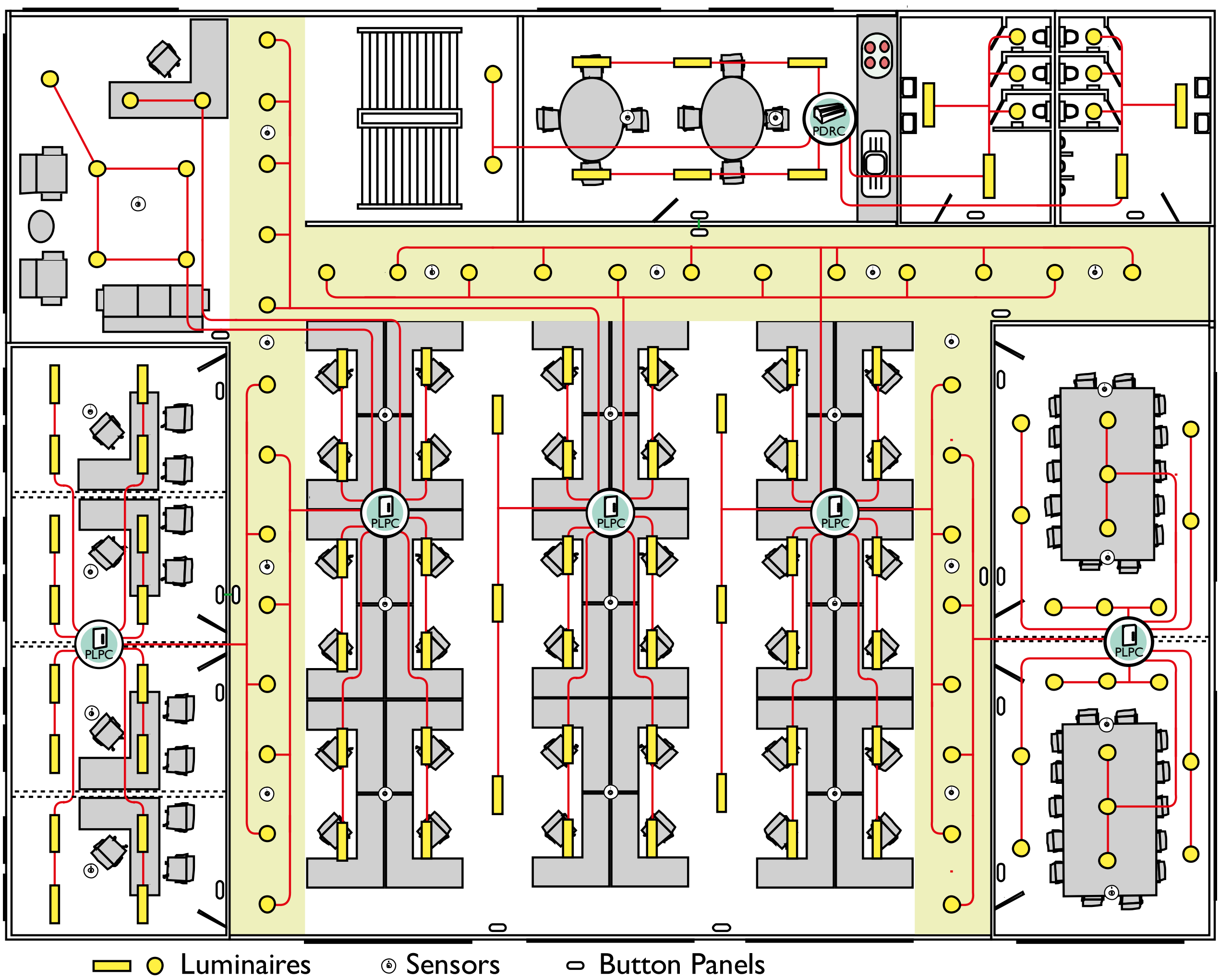


Figure 42 – Actuator placement and load wiring

The position of the actuators in this diagram may differ from where they will be physically located. It is recommended to mount the structured wiring actuators in easily accessible areas.
The PLPC916GL-3-KNX actuators can be mounted above corridors or walkways, and the PDRC816FR actuator can be mounted in a suitable enclosure within the electrical riser cupboard.

6.5 Connecting Devices to the Network

To complete the system, all sensors, button panels and actuators need to be connected to each other via the KNX network. As KNX is a free topology network all devices can be connected to each other in any order. The following diagram illustrates how KNX a network could be structured for this application.

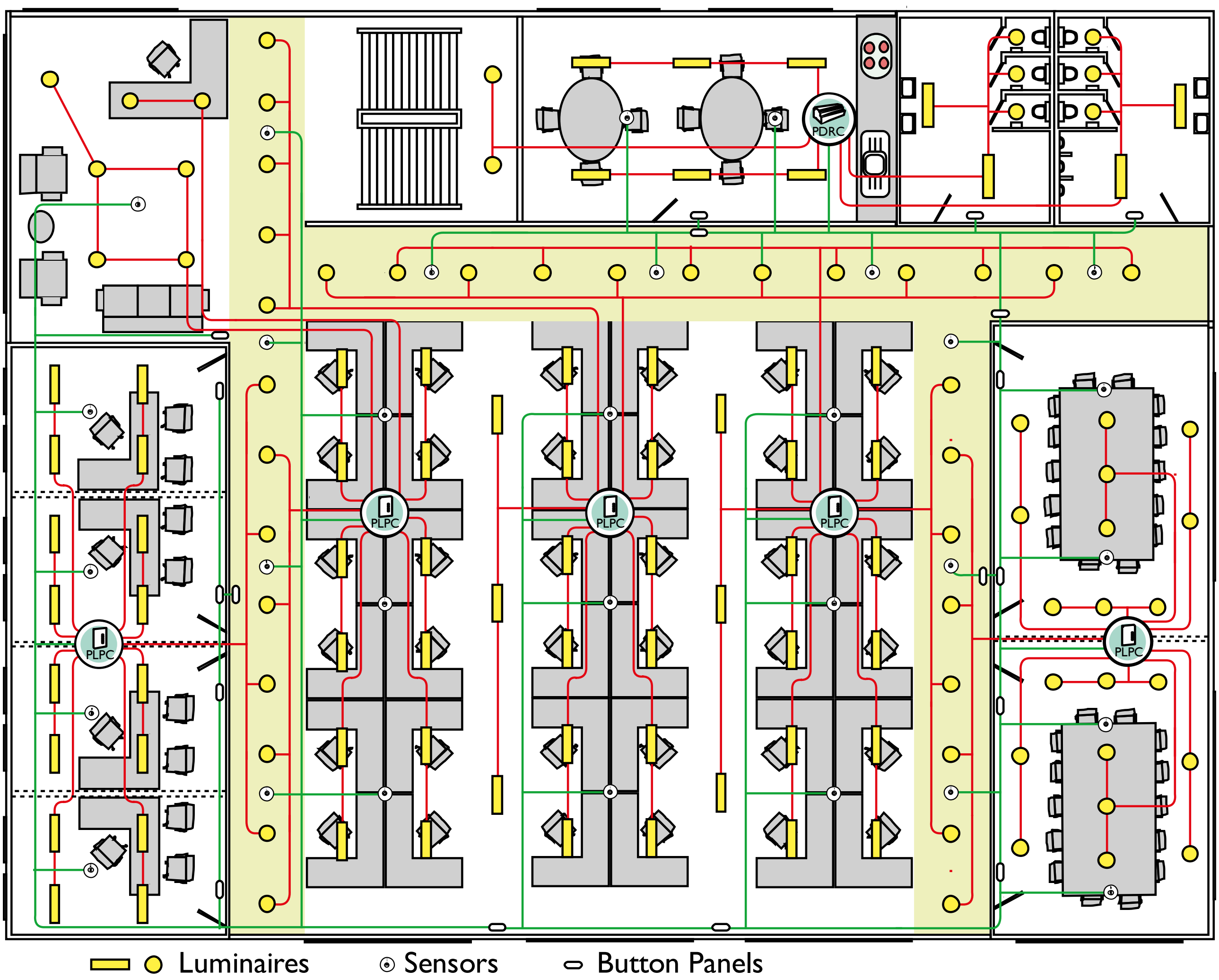


Figure 43 – Actuator locations and network wiring

Following is a single line system representation of the above layout.

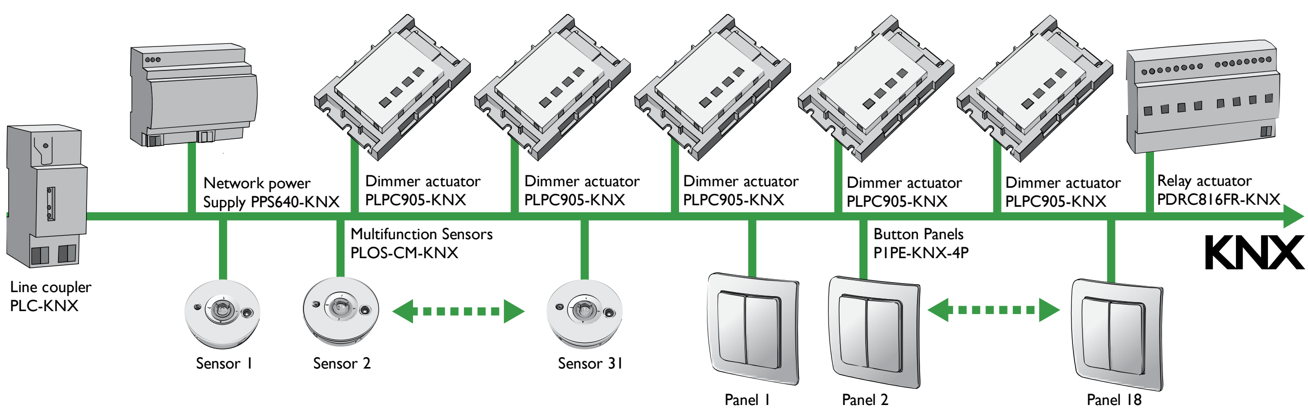


Figure 44 – System Diagram